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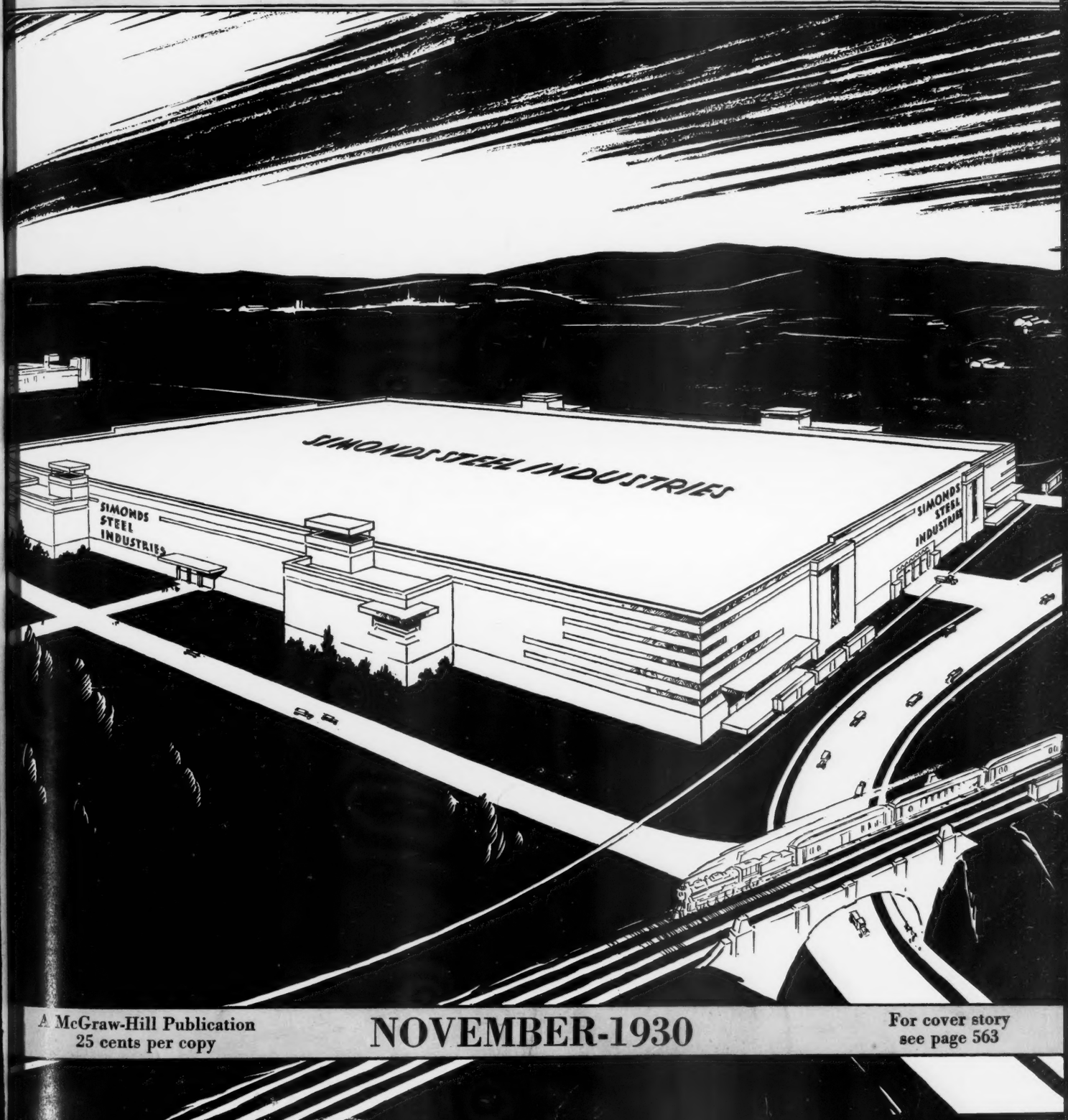
INDUSTRIAL ENGINEERING

MAINTENANCE ENGINEERING
IN PLANTS, MILLS, AND FACTORIES



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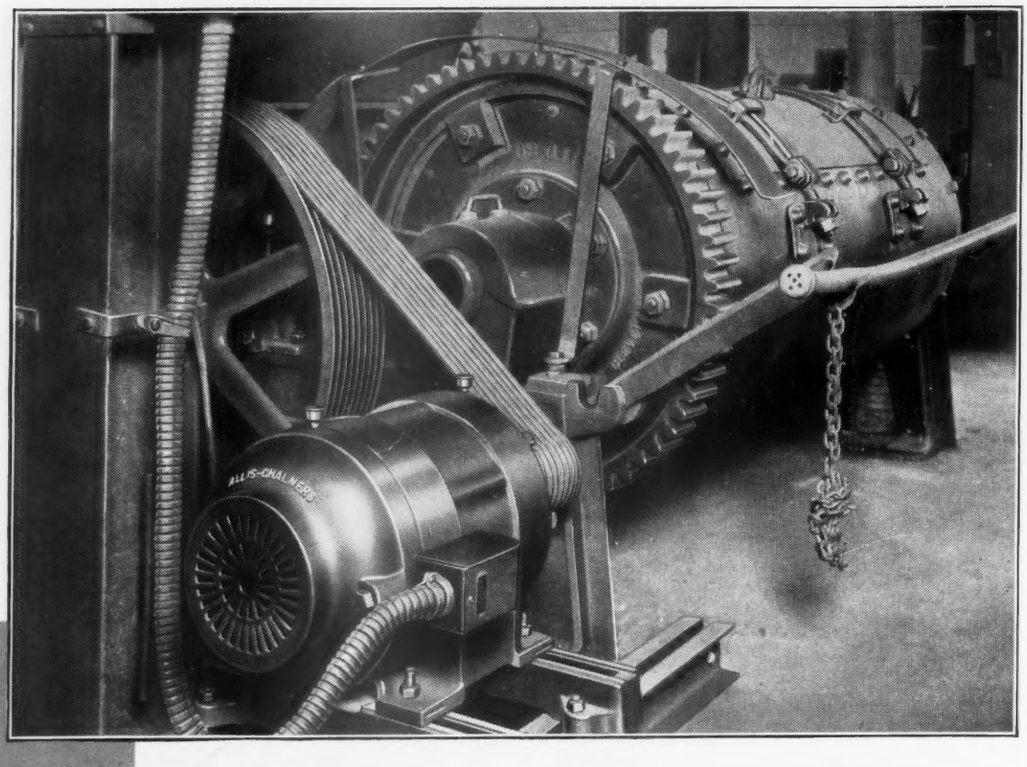
For cover story
see page 563

ARZ motor and Texrope drive operating tumbling mill in an iron foundry cleaning small castings.



Even Iron Dust is Harmless

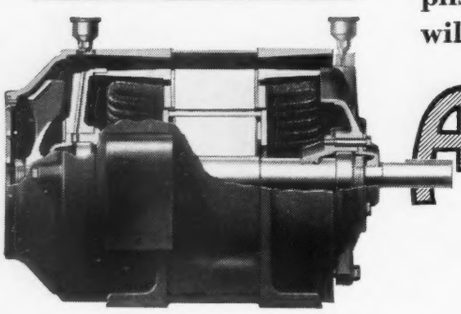
to these enclosed fan-cooled motors

Even in an atmosphere laden with iron dust and fine sand this Allis-Chalmers totally enclosed fan-cooled motor operates without trouble as the dust and dirt cannot get inside the motor.

Previously an open type motor was used for driving the tumbling barrel and required frequent repairing due to the iron dust working through the insulation, causing burnouts.

Allis-Chalmers totally enclosed fan-cooled motors are permanently protected against the effects of dust, dirt, moisture, or similar destructive agents. The unique means by which this protection is accomplished is described in Leaflet 2124, a copy of which will be sent you on request.

This motor is ideally suited for locations where dust, dirt, acid fumes or moisture tend to shorten the life of motor windings. It is particularly applicable to carbon black plants, foundries, cement plants, textile mills, chemical plants, coal preparation or for outdoor service, etc.



ALLIS-CHALMERS

Totally Enclosed Fan-cooled MOTORS

Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin

INDUSTRIAL ENGINEERING

Founded in 1882 as Electrical Review. Consolidated with it—Western Electrician and Industry Illustrated.

Maintenance Engineering in Plants, Mills, and Factories, as Applied to Electrical and Mechanical Equipment and Buildings

L. C. MORROW, *Editor*

Volume 88, Number 11

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Rectangular monitor roofs + paint = increased natural illumination and better ventilation. That's what the Walker Vehicle Company found. See the picture story of this plant, pages 548-553.

And on page 559 we present the first of a series of articles on "Lubricating Systems." This one deals with pressure types. The next will appear in the December issue.

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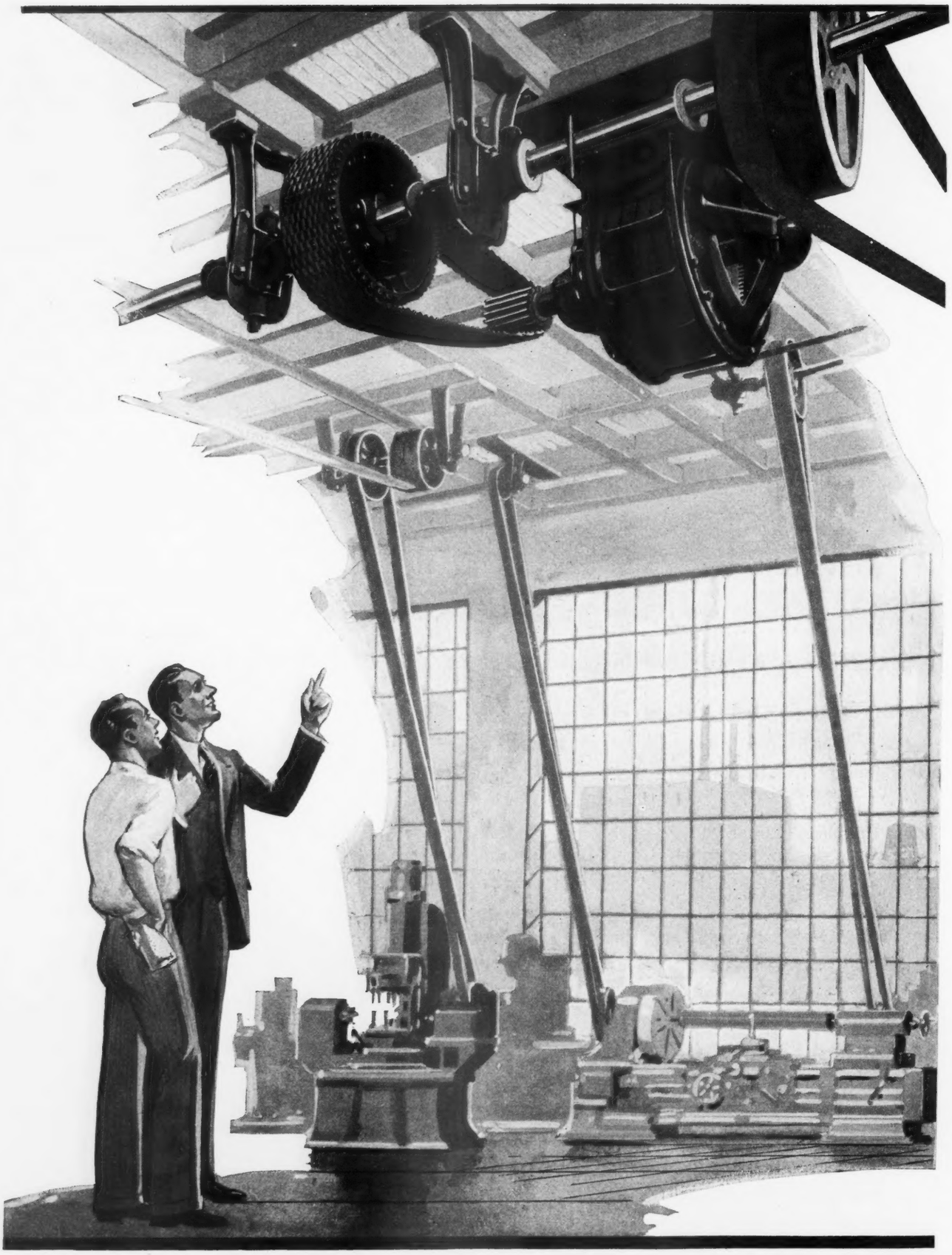

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LINK-BELT

INDUSTRIAL ENGINEERING

Maintenance Engineering in Plants, Mills, and Factories, as Applied to Electrical and Mechanical Equipment and Buildings

A McGraw-Hill Publication, founded 1882

Volume 88 CHICAGO, NOVEMBER, 1930 *Number 11*

BUILT-IN MOTOR PROTECTION

Fig. 1—A 5-hp., 1,800-r.p.m. stator before dipping. . . . . .

. . . . . and after two dips in a moisture-resisting insulating varnish and as many bakings.

By G. R. ANDERSON

Chief Engineer
Fairbanks, Morse & Company
Beloit, Wis.

Protective features contribute to life and service of electric motors

DURING the past few years the popularity of the inclosed motor has increased greatly. Its acceptance has been due not only to the desire of the user for greater reliability and life, but also to the abiiity of the manufacturer to design and develop inclosed motors more nearly suited to individual requirements. As a result, nearly all manufacturers of electric motors now market several types of motors of this class, each designed to serve a particular field.

Any new or increasingly popular product is bound to be overemphasized as a cure-all for all previous ills; therefore it is well, if dealing with a subject as complex as the application of motors, to have a basic knowledge of the methods of rating, degree of protection, and limitations in size as well as all the good features found in different types of inclosed motors.

Moisture-proof windings

Probably the simplest protective feature given to motors in general is the so-called moisture-proof insulation. This protection usually consists of applying extra insulation to all parts of the coils exposed to the atmosphere and giving this insulation several extra protective coats of moisture- and acid-resisting varnish. The effect on the temperature rise of the motor owing to this added insulation is usually not sufficiently large to cause the manufacturer to rerate the motor or design it in a larger frame.

On the other hand moisture-proof insulation does not necessarily mean that the life of the motor will be as long under severe conditions of mois-

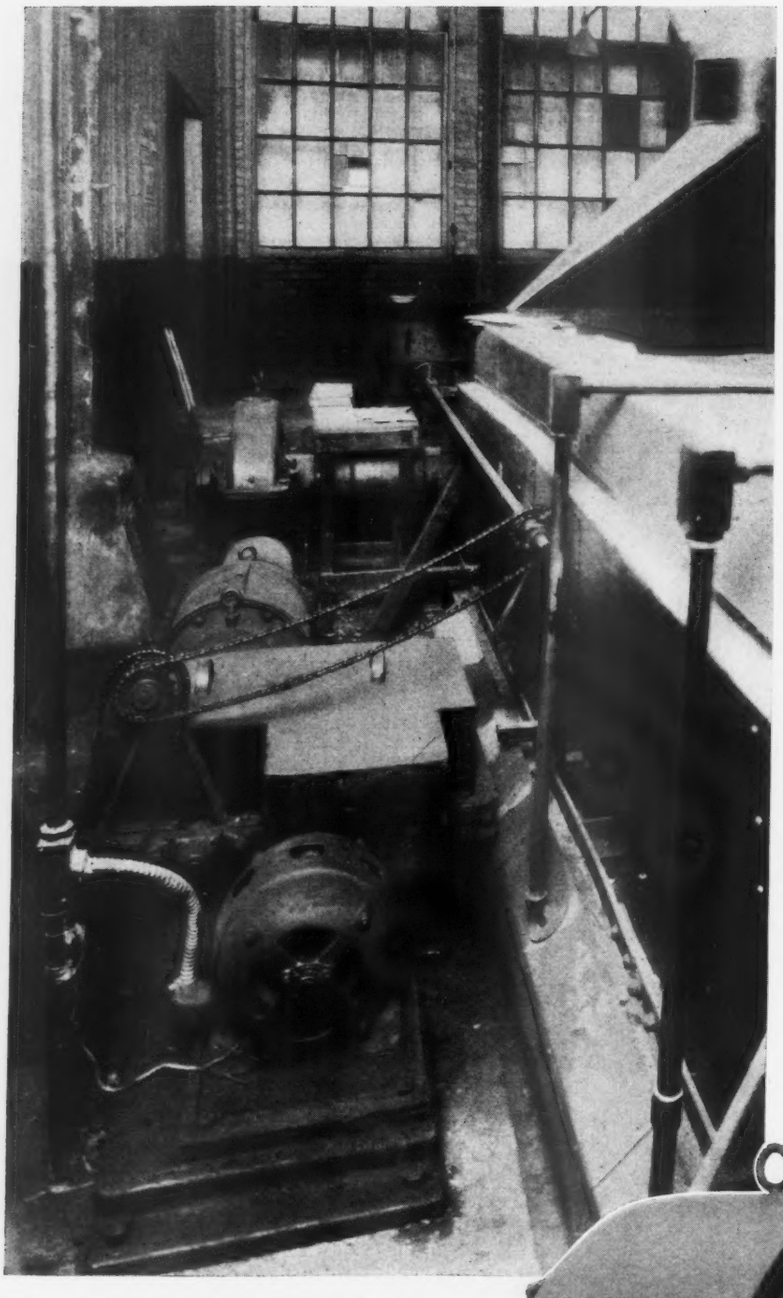


Fig. 2—Suitable winding protection in the form of insulating varnishes enables motors to operate in acid atmospheres encountered in storage-battery manufacture.

ture as would be the case of an open, general-purpose motor operating in a clean, dry atmosphere. It does mean, however, that such insulation will withstand the effects of moisture for a greater length of time than the standard motor. It is intended for use in clean but damp atmospheres, and usually costs the customer an added 5 per cent.

There is illustrated in Fig. 1 a stator before and after it has had applied to it a moisture-resisting, insulating varnish. Another illustration, Fig. 2, shows a motor the windings of which have been impregnated for operation in acid atmospheres.

Drip-proof Motors

About the next simplest protective feature that may be added to a motor is illustrated by the so called drip-proof motor, shown in Fig. 3. This motor is usually a standard open motor fitted with special covers that protect the core and windings from falling water.

These covers are usually designed to cause a minimum of obstruction to the natural ventilation of the motor, thereby enabling the manufacturer to guarantee in many cases, the same temperature rating as is given to the open motor, although in some conditions it may be necessary to allow higher temperatures.

It is interesting to note in this connection that nearly all small, fractional-horsepower motors designed for household and appliance service are of drip-proof design.

Totally Inclosed Motors

This type of motor may or may not be explosion proof. An explosion-proof motor may be defined as a motor so inclosed and constructed that a short or failure inside the motor will not be transmitted to the surrounding atmosphere.

A motor of this class is obviously

Fig. 3—Special covers convert a standard, open motor into a drip-proof motor. These fitted covers protect the core and windings from falling substances.

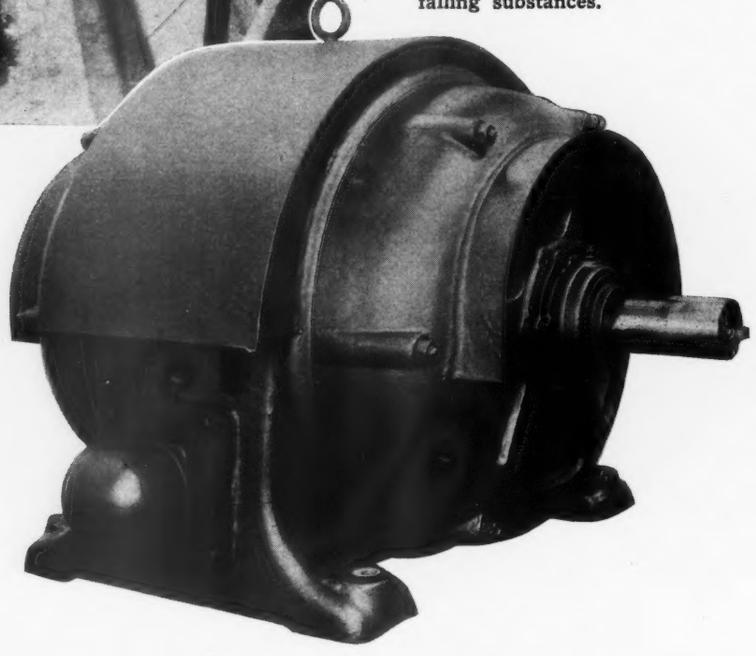
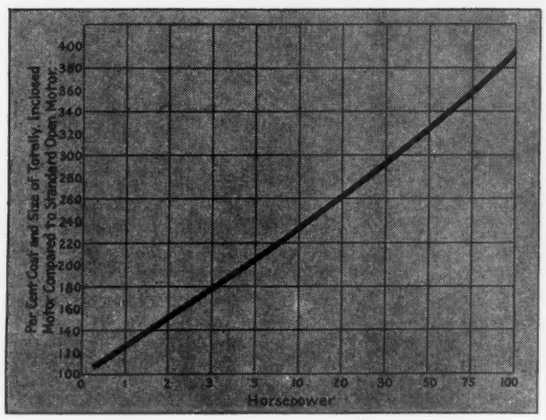


Fig. 5—A type of protecting cover ordinarily found that protects all parts of the motor without interfering with its ventilation.

Fig. 4—Curve showing the relation of cost and size of a totally inclosed motor compared with corresponding values of an open motor.



made extra heavy and strong with extra seals at all joints in its casing. A totally inclosed motor is one whose windings and live parts are entirely shielded from the surrounding atmosphere.

In one case it is the function of the inclosing casing to protect the atmosphere from any failure within the motor, and in the other case it is the function of the casing to protect the vital parts of the motor. This distinction should be borne in mind when considering a motor of this type. An inclosed motor to operate in a highly explosive atmosphere performs a different function than one that operates say, in a foundry.

A further consideration that must be given to inclosed motors is that of temperature rise and time rating. This is extremely important in that it directly affects the size and cost of the motor. It is extremely uneconomical to install a continuous-duty motor for intermittent service.

On the other hand an intermittent-duty motor will soon fail if operated at its rated load continuously. The curve in Fig. 4 shows approximately the relation of cost and size of a totally inclosed motor compared with corresponding values of an open motor, both of continuous rating.

It is interesting to note that for extremely small sizes there is but little difference in size and cost between a totally inclosed and an open motor, but as the ratings get larger the ratio increases very rapidly. It is obvious, therefore, that there will be definite limits where the totally inclosed motor, without external ventilation or other cooling means, becomes impractical. On the other hand a totally inclosed motor of intermittent duty, and of very large rating, may be entirely practical depending on its duty cycle.

Another item to be considered in the case of totally inclosed motors is that of temperature and its method of measurement. The majority of totally inclosed motors are rated at 55 deg. C. temperature rise at a stated load and duty. If measured by thermometer it is only possible to record the temperature of the outside of the motor casing unless holes are drilled that permit the placing of thermometers on the core or the windings.

It is obvious that a 55-deg. C. rise on the outside of casing will mean a much higher temperature rise on the core and windings. The object of rating motors by temperature is obviously to keep the insulation from exceeding a safe working value. Therefore, it should follow that the measurement of temperature should be taken in such a manner that the results obtained give a fair measure of the actual temperatures that the insulation must withstand.

Measurement of temperature by change in resistance is probably preferable for this class. The results obtained represent the average temperature rise of the coils and the values are usually found higher than imbedded thermometer readings owing to the fact that heat must be radiated from the copper through the insulation, nevertheless the consistent use of this method should show more comparable results and be subject to fewer errors and variations than the thermometer method.

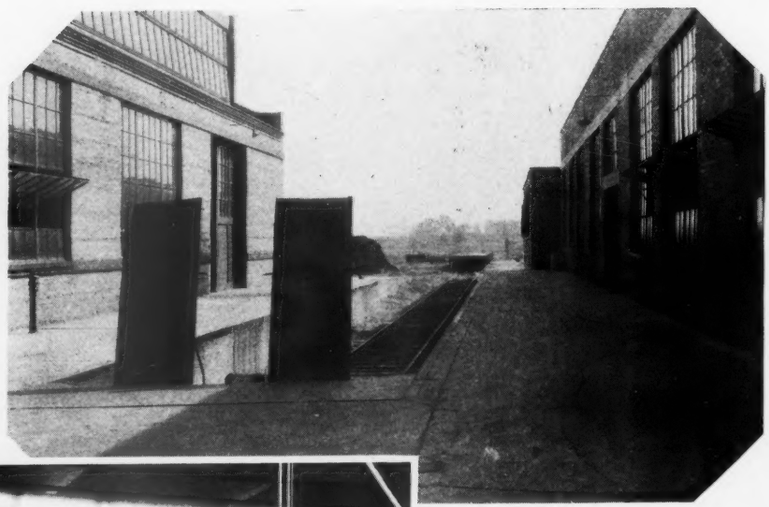
In the case of totally inclosed motors consideration should be given to the class of insulation used. It is obvious that some insulating materials will successfully withstand higher operating temperatures than impregnated cotton or linen. On the other hand they must also successfully withstand potential tests that are usually well defined.

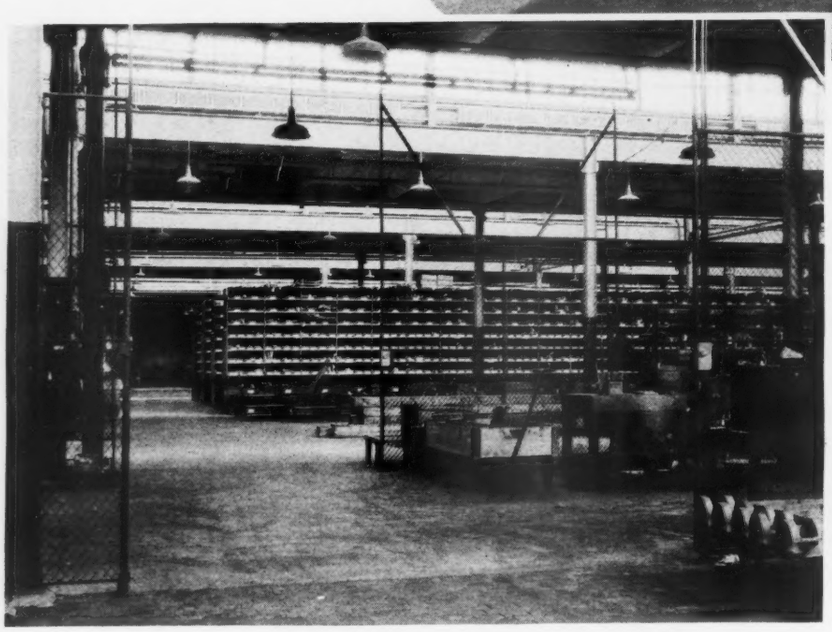
The design and application of totally inclosed motors therefore, presents the problem of determining whether it is the motor or surrounding installation that requires protection, whether the rating and duty are economically feasible and whether the temperature guarantee, method of measurement and class of insulation are properly balanced to insure reliability and long life.

Other designs including inclosed ventilated, and fan-cooled motors will be discussed in an article appearing in an early issue.

AROUND *the* WORKS...

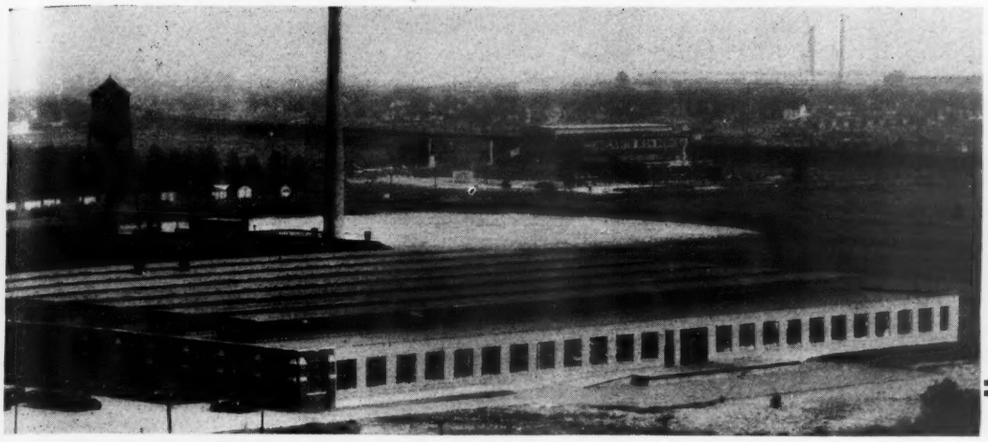
Building construction
Materials-handling
Lighting
Heating
Power transmission
Control
Storage
Sanitation



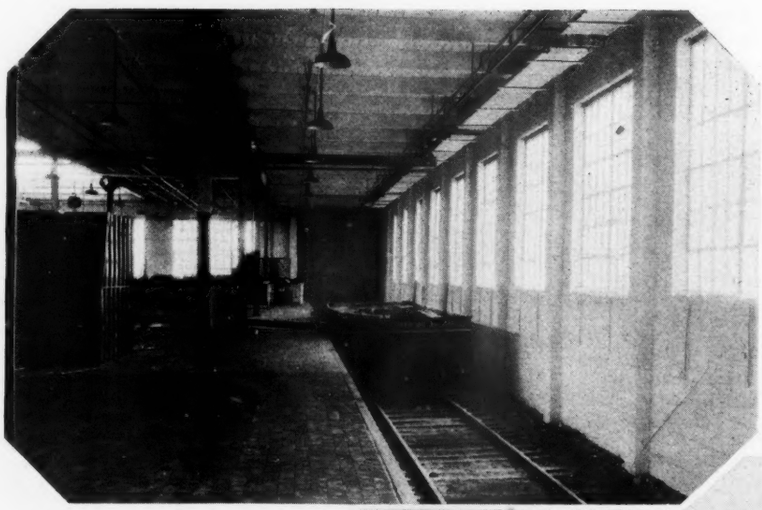


Good enough years ago, when inclement weather and lack of handling facilities meant little to the workmen, was the outside loading platform. Now both indoor and outdoor facilities are available.

Three similar groups of steel shelving behind wire fence in the manufacturing space constitute the stockrooms from which the three companies will draw material. Note the direct-radiation system at the roof level, which extends on both sides of the monitor for the total length of the building.



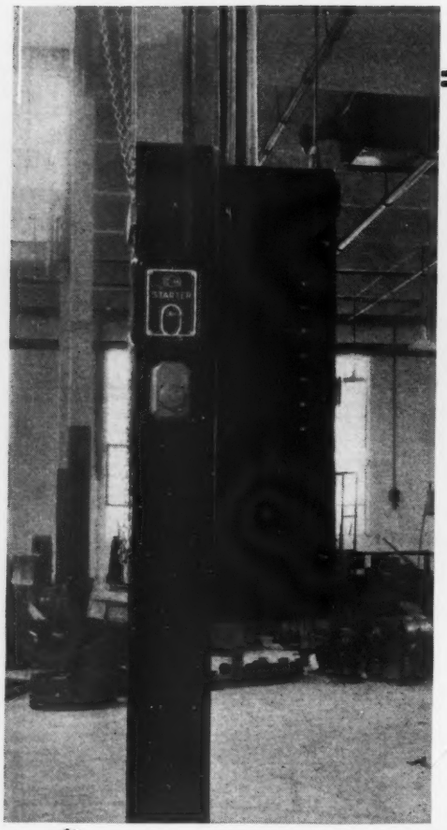
The pictures contrast the new building of the Walker Vehicle Company, Chicago, with the original plant, built and equipped ten years ago. Combined plant now houses the Barrett-Cravens, Walker Vehicle, and Automatic Transportation companies.

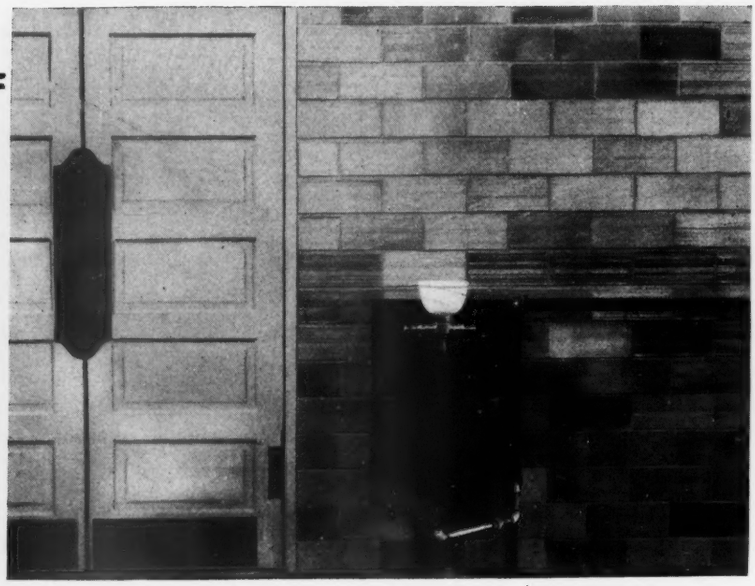


Bird's-eye view of the plant, at the top of this and the preceding page, shows the recent addition in the right foreground, which occupies 300 ft. of the 600x392 ft., total plant space. Both the new and old buildings (at left rear) are of one-story construction. The saw-tooth roof gives way to the rectangular monitor type. Reasons: increased natural illumination and better ventilation.

In the new section of the plant, all-weather loading and unloading dock equipment with modern materials-handling facilities expedites movement of cars and products.

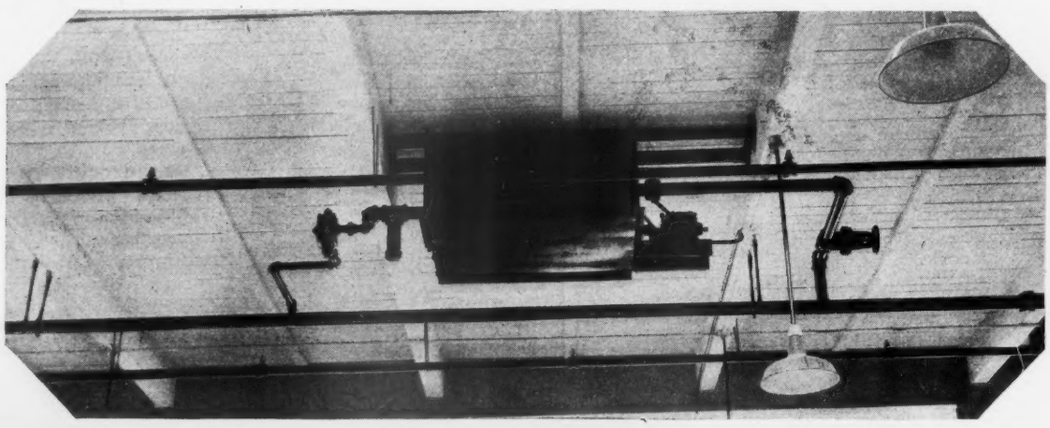
Modern transportation demands corresponding facilities. Materials can be moved by motor truck from the source of supply right to the interior of the plant by making use of the ramp, or they can be relayed from the platform, depending upon the size of objects.





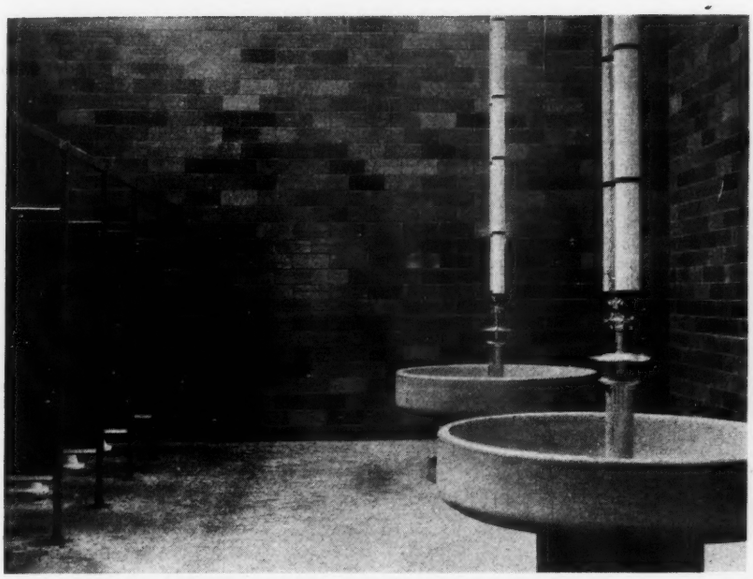
Drinking fountains dispensing cooled water are located at the entrances to the washrooms. Little conveniences that add to employee welfare.

Power and lighting circuits are controlled from convenient locations. Column-mounted unit-heater control-switch, thermostat, and typical lighting panel controlling a section of the 800 lighting units. Each 20x30-ft. bay has four 300-watt lamps which average approximately two watts per square foot.

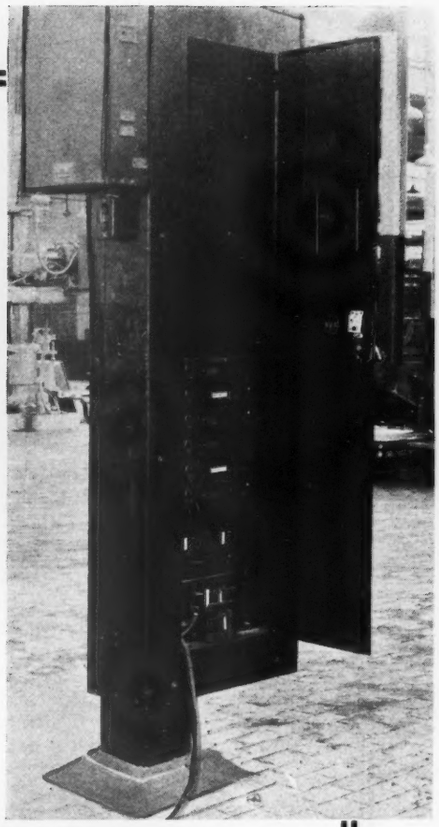


Ceiling-suspended unit heaters, 21 in all, maintain uniform temperature conditions when called upon to make up for a deficiency in the direct-radiatian system.

Some finished products are spray painted. Owing to their nature, unusual clearance is necessary in the roof assembly to permit the product being treated within the booth. This booth is floodlighted through side-wall apertures and equipped with an automatic sprinkler deluge system.



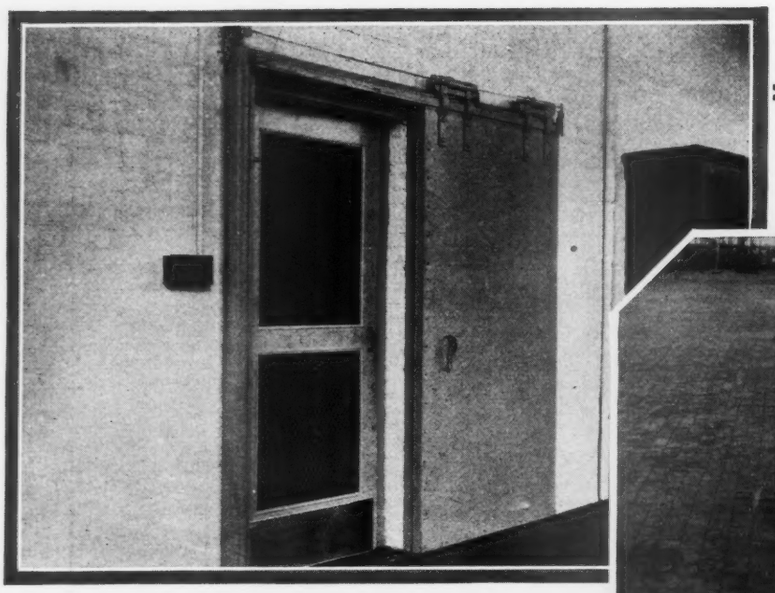
Interior view of a washroom set aside for the employees. These washrooms are tiled inside and outside. The interior walls are washed down with a hose at stated periods. Hot-water pipe fittings are painted blue. A double row of radiators is located overhead.



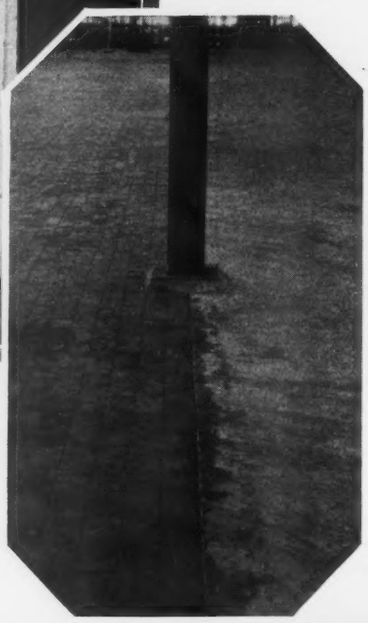
High-tension power is brought into the building underground, to a combined transformer vault and distribution center. Low-voltage feeders extend to distribution panels of the dead-front type.

Two tiled washrooms of the type shown are easily accessible to employees from any section of the recent addition. Their inclusion as plant equipment is indicative of the trend toward employee welfare.

For heating only. Two 300-hp. high-pressure boilers will provide steam to heat plant and office building. Radiators carry the principal heating load whereas unit heaters, thermostatically controlled, will automatically cut in as required to regulate properly inside temperature in severe weather.

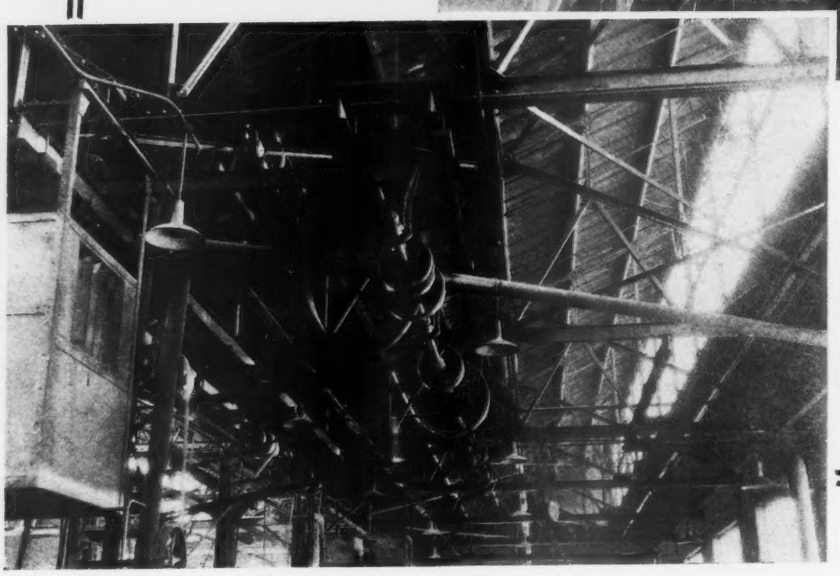


Fire doors stand on guard between office and factory. In case of fire they are automatically closed. Mechanical trips are actuated by rise in temperature on either side of the door.

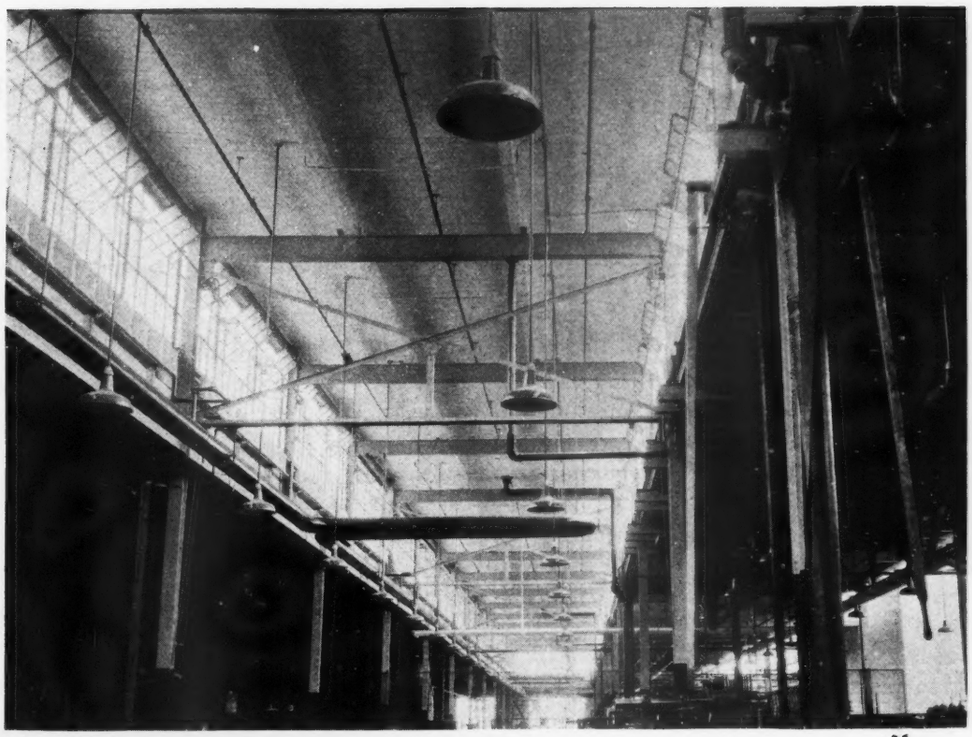


From board flooring in the old plant to wood blocks on end and concrete in the addition. The block floor is used throughout the machine, press, and cutting departments, and where the greatest amount of trucking occurs. Concrete serves the other manufacturing areas.

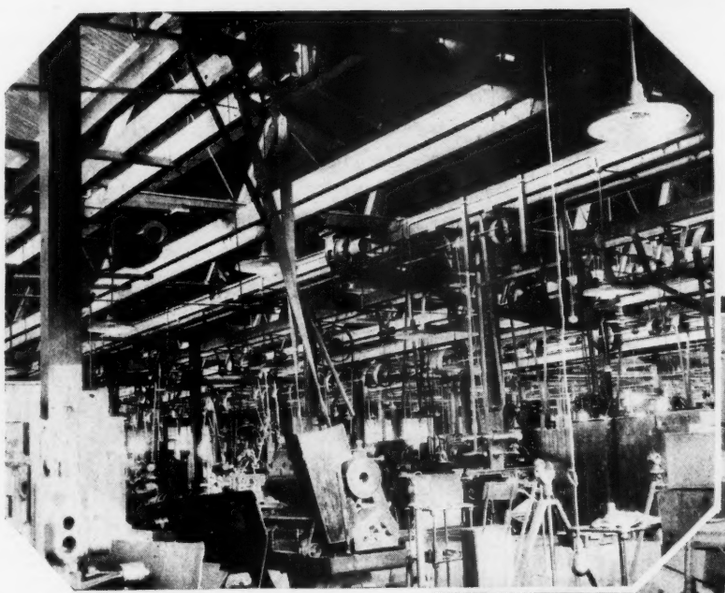
Group drives conform to a standard. In the recent addition all installations are practically the same. Motors are standardized at 25 hp. in capacity. Steel split pulleys are extensively used on antifriction bearing shaft installations.



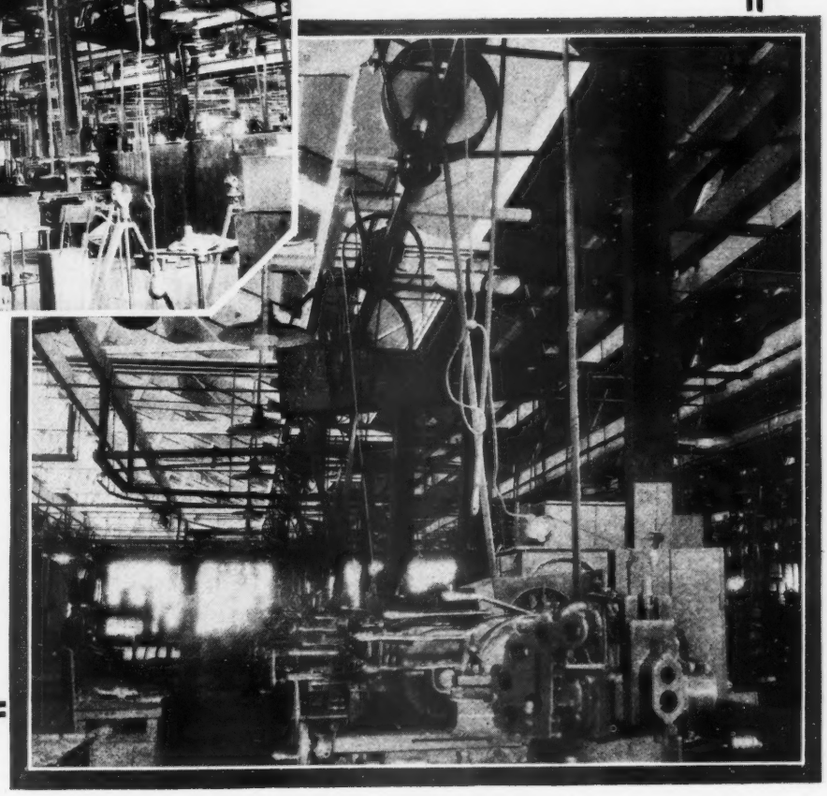
In this section of the older plant, the roof is made up of pre-cast concrete slabs which are sufficiently durable but extremely heavy, necessitating a heavier building framework.



A study in contrasts between the old and the new. Light is at a premium at the lower-left section which is the manufacturing space in the older building. Standing out brightly in the lower right is the transformer vault and power distribution center. Painted ceilings in the rectangular monitor sections reflect light to the space below. In the addition, wood forms the roof base on which is laid the finished roofing material, taking advantage of its light weight and durability.



View in the older plant showing the arrangement of transmission equipment; unpainted saw-tooth roof sections.



Paint applied to the ceiling of the saw-tooth section aids the distribution of light. Coverage with paint throughout the old section of the plant is planned as a result of this experiment. Wood was used entirely in the construction of this section ten years ago.

INDUSTRIAL ENGINEERING

L. C. MORROW, *Editor*

Vol. 88 NOVEMBER, 1930 No. 11

Honoring the Memory of George Westinghouse

BOTH electrical and mechanical engineers rejoice in the tribute paid last month to the memory of George Westinghouse, sixteen years after his death. The tribute was expressed in the form of a memorial erected by those who were associated with him and by the 60,000 employees of the world-wide industries he founded.

If we confess to a feeling of futility in attempting to comment upon the life and works of this great man, our readers will understand. We do so confess, and present, instead of what would be our own inadequate statements, the simply-worded, forceful tributes of Thomas Edison and Gerard Swope:

Said Mr. Edison: "His great achievements and notable contributions to the work of the world entitle him to be regarded as a public benefactor."

And Mr. Swope: "He was an incomparable genius in engineering work, with a great imagination and much courage. He impressed himself forcibly upon all matters he took up and upon all people with whom he came in contact and left an enduring imprint on engineering work, not only in the electrical but also in the mechanical industry."

What a Plant!—We'll Learn Things from This One

BUILDINGS without windows! Orange-colored machines! Blue and green walls! Ultra-violet rays from the lighting units!

Likely to have a revolutionary effect upon plant engineering, so far as building design is concerned, is the new one and a half million dollar plant designed by the Austin Company, of Cleveland, for the Simonds Saw & Steel Company, of Fitchburg, Mass., and just announced.

Lending aid and comfort to the contentions of *Industrial Engineering,* repeated often during the past several months, are these facts: Decision to build at this time is based upon confidence that business recovery is near and that present construction costs are favorable for immediate expansion against future needs. Experiments conducted by the company indicate that an increase in efficiency by as much as 33 per cent may result from uniform artificial light, controlled temperature, absorption of sound, and the use of color.

Features of design are solid walls and roofs without windows or skylights; acoustical walls and ceilings; change of purified and tempered air every ten minutes; heavy machines isolated by cork pads; lighting by means of 1,000-watt lamps.

This plant should prove within a short time the value of its features, both radical and accepted. Plant engineers eagerly will await the publication of results, because of their importance in relation to new construction and to the construction that is a part of plant rehabilitation.

The Steel Industry Scores Another Bull's-Eye

WITH the recent opening of its new plant near Ambridge, Pa., the A. M. Byers Company made public details of a process for manufacturing wrought iron that is not only an outstanding achievement, but one which will profoundly affect the industry. It represents the culmination of fourteen years of intensive study and experimental work, and is another example of the technical skill and business acumen that have placed the steel industry in its present commanding position.

For upwards of 150 years, wrought iron has been made in puddling furnaces by a laborious process of hand working. In a ten-hour turn two puddlers can produce about 2,800 lb. of wrought iron.

In the new process molten pig iron is refined in a Bessemer converter. From the converter the iron is transferred to a machine of special design that pours it slowly and uniformly into a bath of slag whose composition and temperature are very closely controlled. The temperature of the slag is several hundred degrees lower than that of the iron, so that the latter solidifies into granular form when it strikes the slag. When the slag is poured off a ball of granular iron weighing from 6,000 to 8,000 lb. (as compared with the 200-lb. ball produced in the puddling furnace) remains in the ladle. Excess slag is squeezed out and the ball compressed to a size and form suitable for rolling, in a 900-ton electrically driven press. The bloom formed by the press is then rolled into any desired form in the usual manner.

One desirable result of the development of the

new process will doubtless be a wider use of wrought iron in the many applications for which it is admirably suited. Perfection of the new process for manufacturing it is an accomplishment of which any industry or company might well be proud.

Let's Mark Some Roofs for Our Birdmen

WHY not help aviation while we help ourselves? Most factory roofs need paint. Part of that paint can be selected as to color, and put on as to form, so that it will convey definite information to guide flyers. Such an easy thing to do, yet so seldom done!

The American Society of Mechanical Engineers in Chicago is beginning an active campaign to secure the placing of identification marks on the roofs of the Chicago district factories. Fine —Chicago has lots of smoke.

Absence of smoke, however, (if there are manufacturing cities without it) does not make marking unnecessary, especially in the smaller cities and towns. What would the motorist do if he did not have his towns marked on the highways? Drive to the post office, perhaps, or the railway station. The aviator is rather out of luck if he tries that.

Broad-minded Bread Buttering

BIG plants help themselves by helping their little competitors, in an interchange of information. Sounds complicated, happens to be simple. It just can't be helped that the big companies pay the lion's share of the expense of standardization work, research, and development. They contribute more information and more money than do the little companies.

But if they hold out—don't standardize, don't give any information—what happens? The little fellow either becomes a big one or drops out. If he gets big he's able to contribute a full share to the expense. If he drops out, another small company springs up to take his place.

The cause of his dropping out was that he made no profit, which meant that he did not charge enough for his product. His charges were too low because he knew too little about methods, or costs, or equipment. While he was failing his customers were enjoying less-than-cost prices. The industry of which the little plant was a part was not getting all the money to which it was entitled. It would have been better for the industry and for every progressive member of it if the little plant had known enough to be able to make its product at costs that would have permitted it to charge enough to allow profit enough that it could have stayed in the business.

Peculiar thing, the dissemination of information. Most frequently the very act reacts to the benefit of the disseminator. The illustration cited refers to company relations. A little imagination, if exercised, will enable the individual to see how the principle can be applied in his own little industrial activities. Somewhere it was said, "Cast your bread ——."

Electron Tube Control of Motor Speed

WHITHER the application of the electron tube in industry will lead is something that only time can disclose. Certain it is that many schemes utilizing such tubes as the basis of design are being tried, and success is crowning many of these efforts to find cheaper and better ways to accomplish certain results.

An interesting example of power control through electron tubes has recently been made in the wire-drawing shops of the General Electric Company. Proper tension must continuously be maintained on the wire while it is being reeled after drawing. Inasmuch as the wire is drawn at a constant rate, the speed of the rereeling spools must constantly be decreased as layer after layer of wire increases the working diameter of the spool.

Taking advantage of the fact that the rereeling spool is driven by a small d.c. motor, several electron tubes of special type were placed in the armature circuit. A pulley riding on the wire supports the core of a small reactor which controls the current passing through the tubes, and hence through the armature of the rereeling motor. Any change in the position of the core is immediately reflected in the value of the current passing through the tubes.

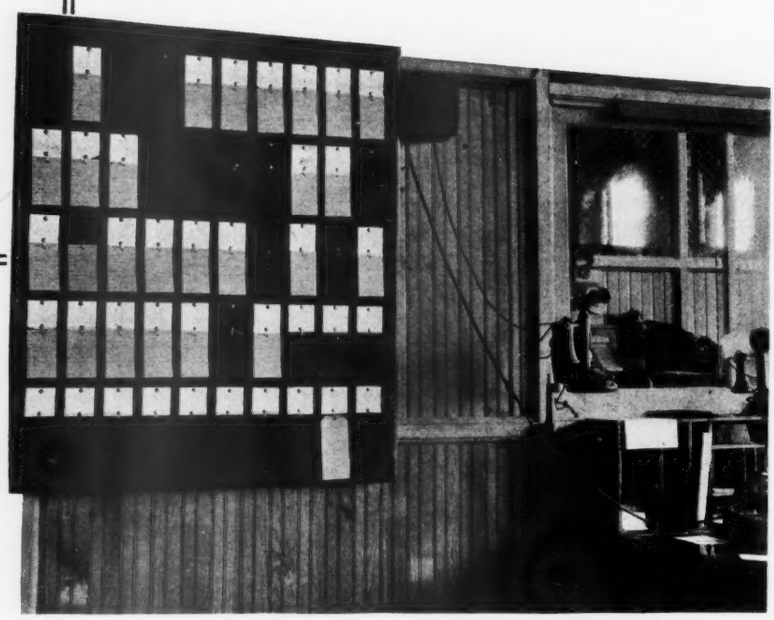
Various kinds of electrical and mechanical devices have been developed to provide the constant change of speed required in different operations, but in many instances these devices have left something to be desired in the way of simplicity and accuracy of control. Use of electron tubes in the armature or field circuit to control speed would at present be limited to small sizes of motors, but it is to be expected that present limitations will be greatly reduced through further development in the design and manufacture of tubes. They may, indeed, well prove to be the solution of many problems involved in securing very accurate and sensitive speed control.

Maintenance by Schedule and Budget

By C. H. BRECHNER

Chief Engineer
Selby Shoe Company
Portsmouth, Ohio

"Scheduled maintenance . . . . . not only controls the size of the plant engineering organization, but also establishes a basis for budgeting next year's maintenance labor allowance . . . . . with its continued use, maintenance labor will cease to be a problem . . . ."



Operating and dispatch center for the supervision of all personnel engaged in maintenance work.

WITHOUT waiting for industry in general to establish a yardstick as a means of determining the size of a plant engineering organization, the Selby Shoe Company, Portsmouth, Ohio, manufacturer of "Arch Preserver" shoes, authorized its plant engineer to proceed with the solution of its maintenance problem, and set up a plant engineering organization that would justify its existence.

From studies of the maintenance work encountered in the daily operation of the plant, and of the personnel engaged in the services-to-production, there has been developed a system of scheduling maintenance which not only controls the size of the plant engineering organization, but also establishes a basis for budgeting next year's maintenance labor allowance from the records of this year's activities. This system has been so successful that it has been adopted by the management and accepted by the personnel without reservation, and with its continued use maintenance labor will cease to be a primary problem at this plant. Guesswork will be replaced by facts accumulated from operating experience.

There is little difference in equipment and personnel to distinguish between this and any other industrial plant; therefore, it follows that there should be little difficulty in establishing the same system elsewhere.

Plant Equipment

This plant consists of buildings, which for various reasons have been divided into groups, all of which provide a production area of approximately 400,000 sq. ft. The oldest building was constructed in 1885 and in 1929 the latest addition was made to the plant. A six-story reinforced concrete structure replaced several antiquated buildings to provide space for anticipated increased production, but during the removal of the old buildings and the construction of the new unit production went on as usual. Equipment and workers were moved into the basement of the new building when the floor of the first floor was poured and could be used as a roof for protection as the building continued to grow. This same procedure was followed as the remaining floors were completed. All buildings, however, are of fire-proof construction and equipped with sprinklers.

Considerable steam is used for winter heating and process work entailing the operation of a boiler plant 24 hr. per day, every day in the year. To distribute steam to every building requires a vast network of pipes, which will be found, especially the mains, in large underground tunnels

connecting all buildings. These tunnels are also used for power conduits, water lines, etc., and in some cases for inter-plant transportation. Service shafts and bridges between buildings also provide for this function at various floor levels.

Air-conditioning equipment is employed to a limited extent throughout the new building. Temperature and humidity are automatically controlled on the various floors although manual supervision can be exercised from the basement; that is, service can be entirely discontinued, but not operated at intermediate degrees from this location. A dual control system governs the operation of the system supplying these services to the offices over the day and night periods.

Power Services

Power is generated as a by-product of the steam produced, but the amount approximates only 25 per cent of the total consumed. About 75 per cent is purchased at the present time inasmuch as the plant is being modernized with a.c. drives and other equipment, which will shortly replace the d.c. equipment remaining. Three-phase, 220-volt service and equipment are replacing the 110-volt d.c. service and equipment as standard. Lighting, however, will be continued at 110 volts. Out of a total demand of 750 kw., lighting takes about 200 kw., the balance being utilized for from 500 to 600 power drives and production machinery, elevators, and so on.

All the foregoing is mentioned to portray the extent of the plant equipment in support of a previous statement made herein, and which refers to a similarity between plants. The need for maintenance and for personnel arises from the same cause.

To provide these very necessary services-to-production for a plant of this type employing around 3,000 persons, there is a plant engineering organization consisting of 40 employees, which represents the present minimum requirement owing to the operation of the system of scheduling maintenance.

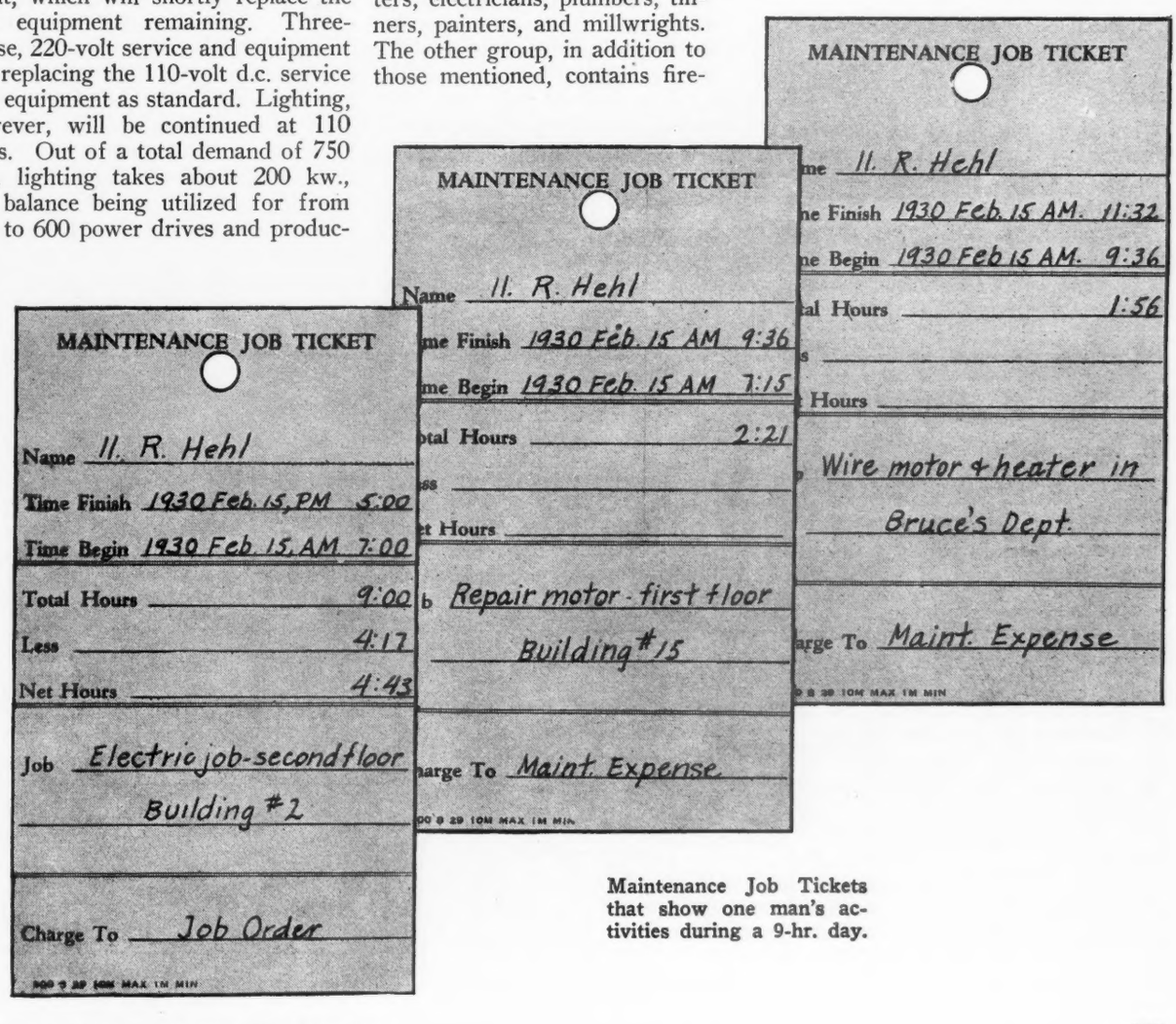
By referring to the chart, it will be seen that the organization is supervised by the chief engineer, who is also plant engineer and the cost control executive. Two foremen report to him. One is responsible for plant maintenance, building construction, etc., having a force of 22 men; the other is in charge of heating services, watchmen, elevator operators, and so on, with a crew of 18 men.

In the first group there are carpenters, electricians, plumbers, tinners, painters, and millwrights. The other group, in addition to those mentioned, contains firemen and enginemen, whose work is practically on a stand-pat basis; that is, they have the same job every day, whereas members of the first group may have several different jobs.

Before the control system was installed oral orders were given, and the length of time taken to do any job assigned to individual members of the crew was nobody's business. No information was available that would explain the high cost of maintenance, the need for maintenance personnel, or the amount of money needed for the next year's activities. The same conditions existed that are common to most other plants, but they too, can find a way out.

Controlling Maintenance

The system is based on a Maintenance Job Ticket. Three tickets shown below illustrate the procedure. Oral orders are no longer given except as explained later on. Each maintenance man is assigned a number, and on a large board hanging in the maintenance headquarters job tickets for the


MAINTENANCE JOB TICKET
Name H. R. Hehl
Time Finish 1930 Feb. 15, PM 5:00
Time Begin 1930 Feb 15, AM 7:00
Total Hours 9:00
Less 4:17
Net Hours 4:43
Job Electric job-second floor Building #2
Charge To Job Order
MAINTENANCE JOB TICKET
Name H. R. Hehl
me Finish 1930 Feb. 15 AM 9:36
me Begin 1930 Feb. 15 AM 7:15
otal Hours 2:21
t Hours
b Repair motor - first floor Building #15
arge To Maint. Expense
MAINTENANCE JOB TICKET
me H. R. Hehl
ne Finish 1930 Feb. 15 AM. 11:32
ne Begin 1930 Feb 15 AM. 9:36
tal Hours 1:56
Hours
Wire motor & heater in Bruce's Dept.
arge To Maint. Expense

Maintenance Job Tickets that show one man's activities during a 9-hr. day.

work to be done are hung each morning on a numbered hook corresponding to the employee's number. These cards are made out by the foreman, and as the men report in the morning they read the instructions on the job ticket, and then go to work. A dispatcher is responsible for stamping the time on the tickets.

If they have been assigned to new construction work such as the installation of a substation to control the distribution of a.c. power in the new building, only one card per man will be filled out, and at the end of the 9-hr. day these job tickets, when the men punch out, will show 9 hours of work per man against new construction work. Work of this character is given a job number which is issued by the accounting department to govern the expenditures against this class of work. At the present time regular maintenance is not covered by a job number, but when the system is completed job numbers will be assigned for production departments which will be required to budget their anticipated maintenance requirements for the succeeding year.

In the preceding paragraph the case was given for the men assigned to one job which kept them occupied the entire day. By referring to the illustration of the job tickets the necessity for three cards will explain the operation of the system where a man does more than one job per day.

This employee is No. 11, and he punched in at 7:00 a. m. The foreman assigned him to a new construction job bearing a job order. At 7:15 that morning trouble developed in a motor on the first floor of building No. 15. The production foreman reported the trouble to the maintenance foreman, who ordered No. 11 from his major job to make the necessary repairs to the motor in building No. 15. The maintenance foreman's dispatcher made up a new card then for this assignment, entering on it the time No. 11 left for building No. 15. Instead of returning to headquarters at the completion of this emergency job, No. 11 reported by phone to the dispatcher, who entered the time the job was completed, and the total period of time required, which amounted to 2 hr. 21 min. This time was charged to maintenance expense.

At 9:36, No. 11 would have returned to his major job, but, while working on the motor repair job in building No. 15, he was directed by the dispatcher to wire a motor and a heater in another department. The dispatcher made out another card entering on it the time No. 11 went to this job and which detained him until 11:32 a. m. Reporting to the dispatcher by phone the time of completing this job, he then returned to the first job to finish up the day. The dispatcher calculated the time spent on the last job to be 1 hr. 56 min.

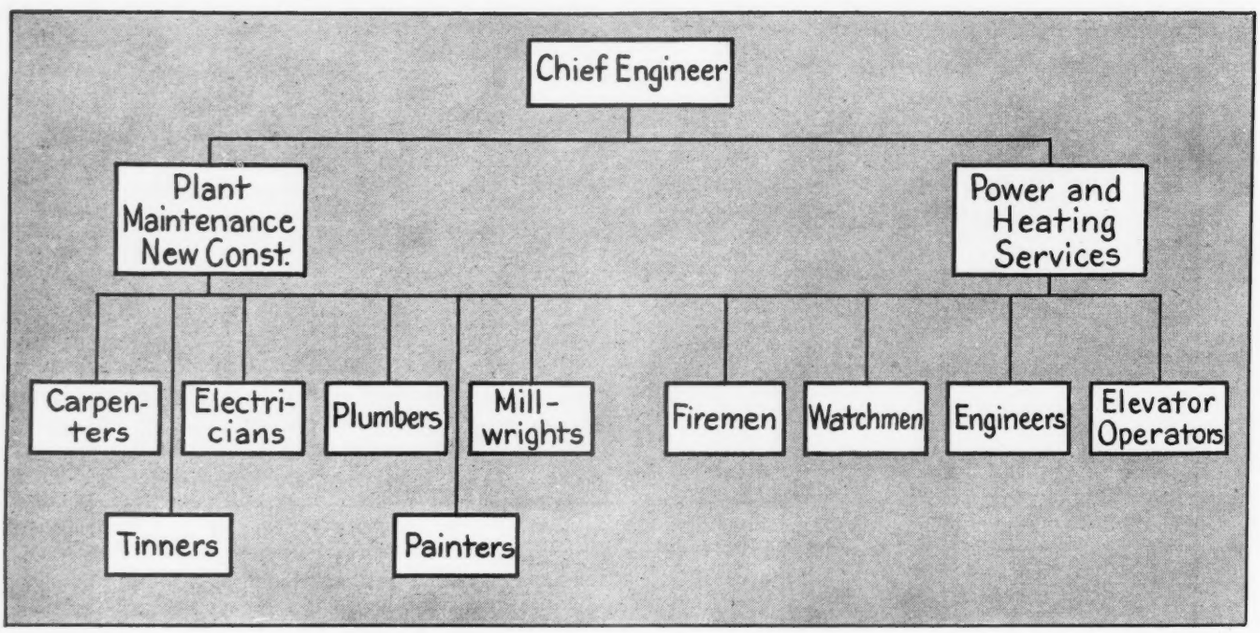
These cards are kept on No. 11's hook and at the end of the day show what he has accomplished as well as the nature of the work. The total time away from the major job is subtracted from the daily total as of the job order card against which will be charged the difference, or 4 hr. 43 min., which represents the time No. 11 gave to that assignment. For an emergency job the dispatcher may assign a workman to it without hunting up the foreman to obtain his approval.

This same procedure is applied to every member in this department. All cards are carefully scanned, and inquiries are made when the time taken to do a job seems out of proportion to the time normally required.

It is at this point that the system aids in limiting the size of the department. Where excessive time is charged to a simple repair job, it indicates that there is insufficient work to be done, or the employee is out of step with the organization. In either case the department is reduced by one employee.

This force reduction is continued until the amount of work is sufficient to keep every man occupied every minute of the day, and as maintenance work increases beyond the ability of the force to complete it within a reasonable time additions are made to the department.

Each week a balance sheet is made out from the maintenance job tickets. By segregating the job order cards the time to be charged against regular maintenance is determined by subtracting the amount charged to new construction work from the total time worked. The total weekly maintenance labor cost is figured from the day rates paid each man for the time



Organization chart for plant engineering department.

engaged only on maintenance work. This total is then compared against the amount budgeted, which has been reduced to a weekly basis, and the increase or decrease becomes a matter of record for budgeting next year's maintenance allowance.

Consistent savings shown for actual maintenance work over the year indicate that the amount budgeted was excessive, and if no changes in operation are anticipated the amount to be budgeted for the next year's operation can be determined by reducing the previous figure in proportion to the savings shown. If this total is insufficient to cover the year's activities the card system will show it. In this event, all that is necessary, if one is to operate on a control system of this kind, is to increase the amount previously scheduled for maintenance in proportion to the deficit incurred.

LUBRICATING SYSTEMS

Pressure Types

By FRED H. LOW
Mechanical Engineer

The first article of a series

DEPENDENT upon the method of application of the lubricant, lubricating systems may be classified as: Pressure, gravity, oil bath, flood, wipe, oil ring, and oilless.

Pressure systems discussed here include all systems wherein the lubricant is applied to the bearing surfaces under pressure other than that exerted by gravity, capillarity, or the atmosphere. Such systems range in pressure from those handling light oils under a few pounds up through those handling greases or semi-fluid oils under several tons pressure.

Systems of so called central-automatic lubrication, wherein the lubricant is supplied to several bearings from a single unit and which have for a long time been used in the engine room and on locomotives and lately on automobiles, are now finding wide application in the shop.

Although central-oiling systems have been highly developed for some time, the development of the central-automatic greasing system is of rather recent date. It is used primarily for lubricating slow-moving bearings in which high pressures are encountered or where oil has a tendency to run out, but also is being applied successfully to machine tools.

One of these equipments is shown in Fig. 1. In this unit, the grease is forced from a cylinder by air pressure furnished by a small, motor-driven compressor. An automatic pressure switch cuts-in and cuts-out the motor driving the compressor, which maintains the pressure between the desired limits. In one of the systems made by the manufacturer of the equipment just described, the grease goes directly into a distributing head.

In the equipment shown it enters a distributing cylinder which is revolved by means of a separate motor and speed reducer. An inlet port or ports index with outlet ports in the case, thus distributing grease to each outlet each revolution. Operation of the distributor is controlled by an electric clock, which may be set to function at any predetermined time period.

To prevent the distributor from stopping on an open port, a drum-control switch is employed, the function of which is to keep the distributor in motion until the safety zone is reached. At this point the shunt electric brake operates and stops the motor.

Pilot lights indicate the operation of the distributor. Closing the motor circuit causes the first pilot lamp to be lighted; then when the motor starts the drum switch which is connected to the distributor, completes a circuit to a second lamp.

A by-pass switch permits the distributor to be operated without changing the setting of the clock.

Although the system shown is a compact unit, it may be operated with its major component parts at different locations.

Timed control is particularly desirable where very small quantities of lubricant are needed. It can be used also to effect a saving in lubricant on installations using larger amounts. However, satisfactory results are obtained with direct application of the lubricant to the bearings under a constant pressure.

In either type of installation a metering valve is used to insure the proper amount of lubricant being delivered from the header to the bearing. In its simplest form the valve is nothing more than a petcock. Where very fine adjustment is desired, needle-type valves are used. A combination of two valves permits closing off a bearing without disturbing the normal adjustment while the quick-release regulating valve, the needle of which may be quickly raised from and returned to its seat, permits the bearing to be flushed.

The size of pipe used in conveying the grease to the bearings varies according to the magnitude of the installation, but, where a single header line is used, piping 1¼ or 1½ in. in diameter is preferred with ½-in. pipe

leads from the header to the bearing. Connections are made to bearings which are subject to extreme vibration, also to bearings such as cranks, eccentrics, etc., by means of grease-proof rubber hose or heavy, metal, flexible hose.

Many of these central systems are driven from some moving part of the machine they lubricate. Fig. 2 shows one of these units designed to handle grease.

In some cases the grease is contained in a reservoir above the pumping unit. A scoop and helical disk feeder, driven from the pump drive shaft, assist the grease in flowing into the pump chambers.

Grouped about a central shaft are the pumps. Each pump has two discharge connections and will supply two bearings requiring approximately the same amount of grease. These lubricators are similar in design to the oil-handling pumps offered by the same manufacturer. Each pump both measures and forces the grease into the bearing, the action of which may be described as follows:

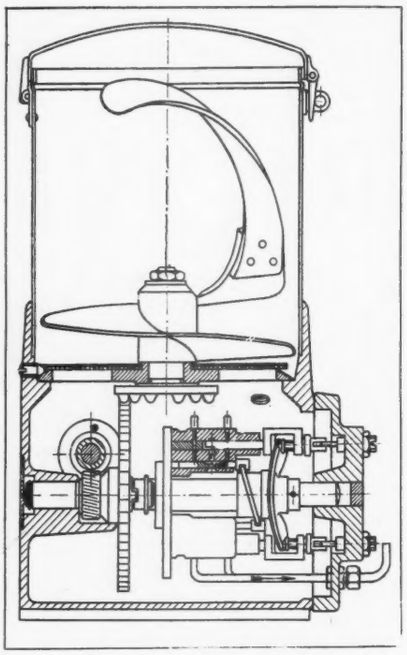
Attached to a central shaft are two disk cams. The lower disk engages a yoke on the stem of each valve plunger while the top disk engages the piston yokes. Rotation of the shaft causes these members to move up and down in their chambers.

With the pump on one side on the suction stroke, its piston draws the grease into the cylinder through a hole in the valve plunger. On the opposite side, the pump is on the delivery stroke. The hole in the valve plunger has moved down closing the port in the suction line and the grease passes through a groove in the plunger into the outlet pipe.

As the pressure required to force the grease through the leads is rather high, the drive shaft should be driven positively from some suitable part of the engine or machine. With reciprocating parts, connecting links should be used; with rotating shafts, an eccentric sheaf may be used. Either of these connections engages the roller ratchet and oscillating lever of the grease lubricator.

The rate of feed is controlled, first, by the drive and the ratio between the drive and pump shafts; and second, by the adjustment of the individual pump unit. A minor adjustment also is obtained by a variation of the oscillating lever. Adjustment of the individual pumps is effected by means of a screw in the piston yoke. As this screw is backed out, the opening in the yoke is increased. Part of the cam action is lost in changing the direction of the piston travel with a subsequent reduction in the length of its stroke.

These lubricators are provided with hand cranks which are used in priming the system when starting and flushing the bearings when necessary.



Courtesy Robert Bosch Magneto Company, Inc.

Fig. 2—Some grease handling systems are driven from the machine they lubricate. Drive may be roller, ratchet, or oscillating lever. Permissible back pressure 1,500 lb. per sq. in. Rate of grease feed per outlet 0.0078 fluid ounce per stroke.

All manufacturers of lubricating equipment realize the importance of keeping dirt and foreign matter out of the system. Not only do they cause excessive wear; they are likely to affect the operation of the entire system. For this reason these systems are always equipped with adequate filters or strainers. Users are cautioned about handling lubricant.

There are several central automatic systems designed to handle oil, some of which also will handle semi-fluid oils. Generally, these systems consist of a force pump, a metering device, terminal fittings, and the necessary piping. All of these parts vary with the different makes, and in a few cases, distinctive features of distribution are introduced.

An equipment similar to that already described is furnished for handling oil. The action of the pumps and the method of adjustment are the same. Such oilers are manufactured in a variety of types and combinations to meet different requirements. They may be obtained with oil reservoir or as separate units for installation with available tanks.

By the use of special disk cams, the pumps may be made to deliver oil twice per revolution of the center shaft, and by a slight change in the valve plunger ports and cam it is possible to have one pump alternately feed two outlets. Both of these outlets may be used to feed bearings or one of them used as a drip-sight feed, the oil returning to the reservoir.

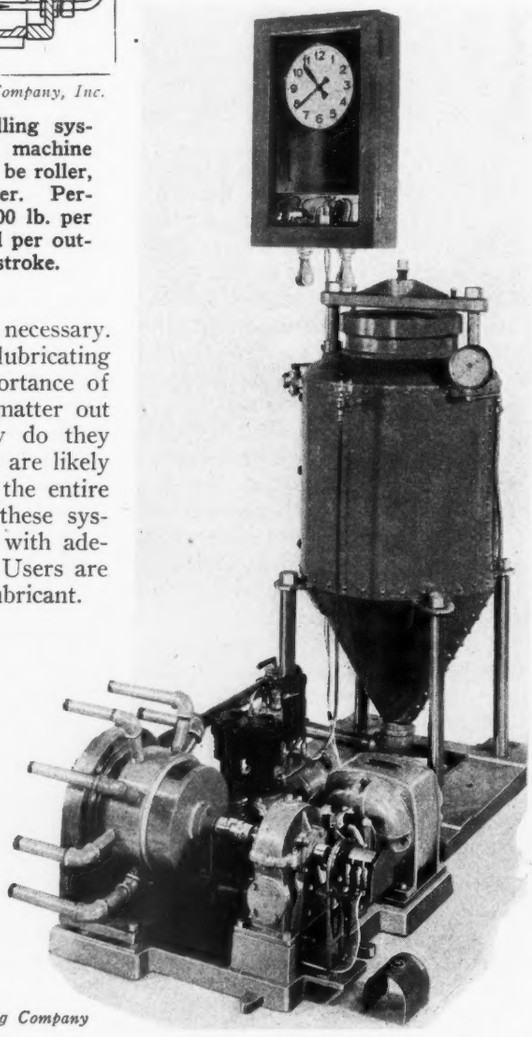
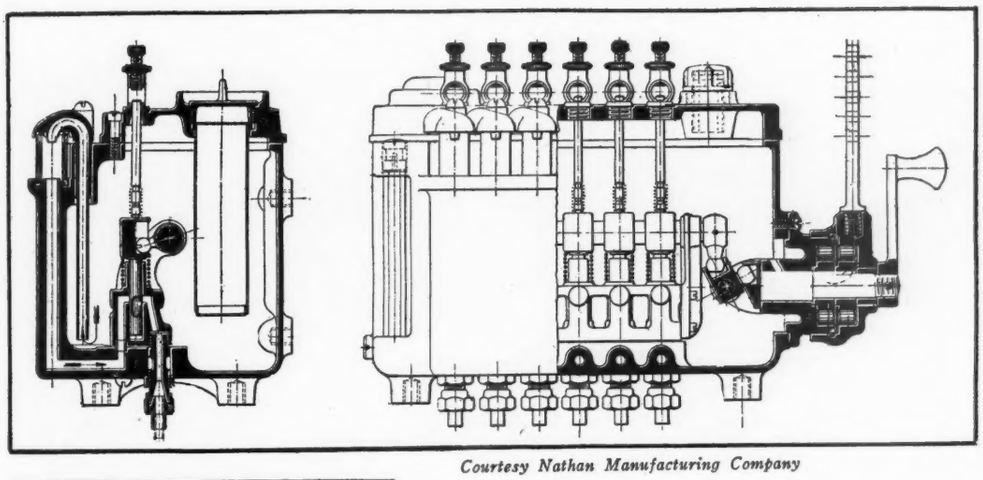


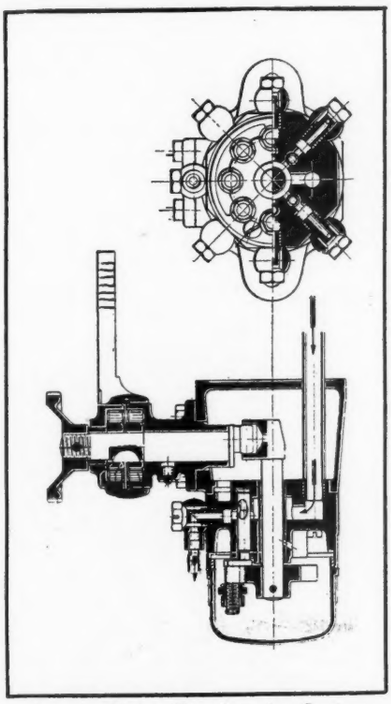
Fig. 1 — Central automatic systems for handling lubricants are finding a place in the shop. Operation is clock-controlled for pre-determined amounts to be supplied.

Courtesy Keystone Lubricating Company



Courtesy Nathan Manufacturing Company

Fig. 4—Using the same method of pumping as the device shown in Fig. 3, this unit is equipped with sight feed.



Courtesy Nathan Manufacturing Company

Fig. 3—In this design the pumps are grouped around a central shaft which imparts an oscillating as well as a reciprocating motion to the piston.

Obviously, the unit will function properly with the shaft turning in either direction, thus permitting its use on reversible machines.

Another lubricating unit in which the pumps are grouped about a central shaft is shown in Fig. 3. In this lubricator an eccentric on the end of the driven shaft engages the vertical shaft in such a way as to impart an oscillating as well as a reciprocating motion. This oscillating motion is imparted to the pistons, the ports of which are indexed with the inlet and delivery ports, so that no check valves are required. Check valves are recommended, however, at the point of application to prevent the oil from leaking out of the leads. This precaution is particularly important when starting a machine, for if there were no oil in the lead it would be some time before the bearing would receive lubrication.

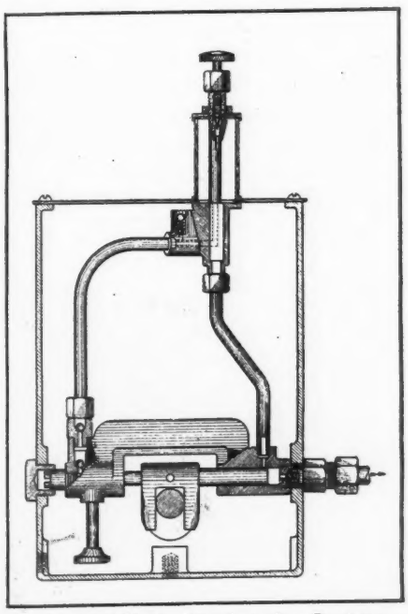
These units, which are provided for either ratchet or rotary drive, are supplied as pump heads for installation on any tank, or they are furnished complete with reservoir. If not all of the outlets are required, one or more of the pistons may be removed and the outlets plugged.

Regulation of the quantity of oil delivered is made by means of an adjusting screw on the end of the piston shaft. This adjustment increases or decreases the vertical clearance in the socket through which the piston is connected to the central driving shaft, permitting that shaft to extend more or less in its movement of free travel thus reducing the stroke of the piston. Any quantity of oil up to 0.010 cu. in. per min. may be supplied against back pressures up to 2,800 pounds.

Working on the same principle of opening and closing the ports by means of the piston oscillation, but having sight feed, is the unit shown in Fig. 4. Here, the pumps are laid out along a horizontal shaft which is operated through a toggle joint by means of a ball eccentric on the end of the ratchet shaft. This arrangement not only turns the shaft back and forth, the motion of which raises and lowers the pistons, but the toggle joint being held, it imparts a reciprocating motion that causes the pistons to oscillate.

Sight feed is obtained by having the suction connected through a drip nozzle. The quantity of oil is varied by adjusting the piston stroke, as already described.

A simple pumping unit of rugged construction is shown in Fig. 5. All working parts are submerged in oil and inclosed in the oil reservoir. Cams on the layshaft, working in yokes, cause the two pistons which are attached to each yoke to move back and forth in their respective cylinders. A pair of pumps is required for each outlet. The pump shown to the left receives and delivers, through ball check valves, an excess of oil which is forced up to the adjustable sight feed. Here the desired flow of oil is obtained by means of a needle valve. The oil in excess of the requirement for the



Courtesy Krahn Manufacturing Company

Fig. 5—Adjustment of the oil flow is obtained by means of a needle valve. The oil is drawn by the plunger through the inlet pipe into the cylinder. On the return stroke of the plunger the oil is forced up the inlet pipe, past the by-pass valve, into the regulating valve, from where it drops from the drip-nozzle through the sight feed and outlet pipe into the cylinder and is forced out into the feed line.

bearing is returned to the reservoir through a relief valve located just under the cover.

This equipment is available in single- or multiple-pump units for either oscillating or rotary drive. An auxiliary hand lever is furnished with the ratchet pump, and a disengaging head with the direct-drive pump, so that oil may be forced into the bearings before starting.

Although single tanks are generally used, compartment pumps, enabling the use of two grades of oil in the same unit, are available.

There is also available a pressure system in which air pressure in the oil reservoir forces the oil to the point of application or to the headers where the flow is controlled by sight-drip pressure feeders, similar to those previously described.

Another system using the cam and yoke principle of drive, shown in Fig. 6, makes use of a different method in metering the oil. The pumping unit is installed in the tank in a vertical instead of a horizontal position.

Submerged in the oil is the metering pump which draws in the oil on the upward stroke of the piston through the valveless inlet port. On the downward stroke, the piston covers this port. As its travel continues the entrapped oil is forced through a recess in the piston and discharged through a ball check to the drip nozzle of the sight feed. From there it drops into a small reservoir whence it is drawn into the force pump and delivered into the line leading to the bearing.

The amount of oil delivered is regulated by turning the knurled nut on the end of the adjusting rod. This rod raises or lowers the combined cylinder and valve unit of the metering pump. As this unit is lowered, the closing of the inlet port by the piston is delayed, thereby reducing the quantity of lubricant handled per unit per stroke. Thus, part of the oil will be returned to the reservoir and a smaller quantity will be delivered to the force pump. All of the oil delivered to the pump is forced into the line at each stroke.

Usually this apparatus is driven from some moving part of the equipment it lubricates; however, motor-driven units are also supplied. The latter are used where it is difficult or impossible to obtain a drive from the equipment or where it is desired to have a central system to lubricate several machines or equipments.

Relief and shut-off valves are installed in each lead from this apparatus so that the supply of oil may be cut off from any machinery that may be shut down without disturbing the normal adjustment.

Another type of pumping unit furnished by the same manufacturer is shown in Fig. 7. In this unit a single pump supplies the oil through individual adjustable sight feeds to the force pumps.

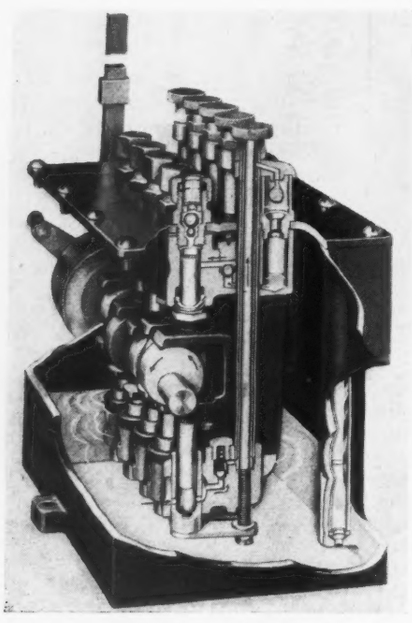
Oil from the supply pump is circulated against the pressure of a relief valve through a header from which it is metered by means of needle valves. From these valves the oil passes through the sight-feed drip-nozzles whence it is forced into the individual lines by their respective pumps.

At the return end of the header is a quick-acting valve which is normally open. When additional oil is required for flushing the bearings, this valve is closed, forcing all of the oil to discharge through the sight feeds. When the bearings have been flushed the valve is opened, permitting the system to resume its normal flow.

Ball check valves are used throughout, except at the inlet ports of the pumps, which are opened and closed by the piston as mentioned in the description of the preceding system.

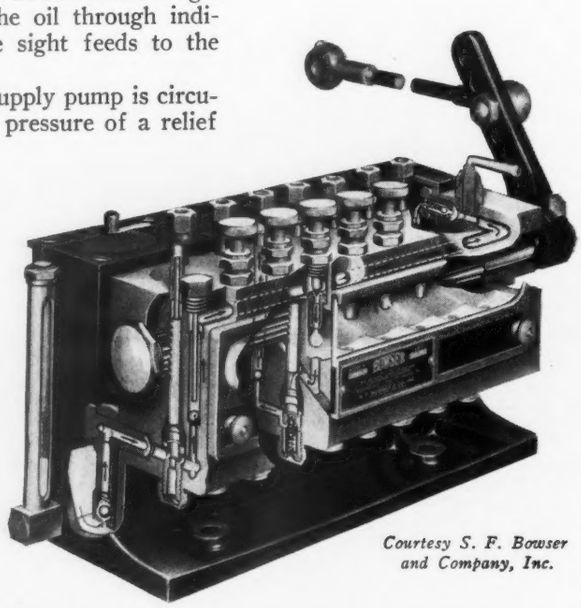
The pumps are driven by means of gear teeth on the drive shaft engaging racks on the piston stems. The rocking motion of this shaft is obtained from some reciprocating part of the machine acting on a lever. A series of holes in the lever permits a slight adjustment of the movement to keep it within the limits of travel.

The second article will appear in an early issue.



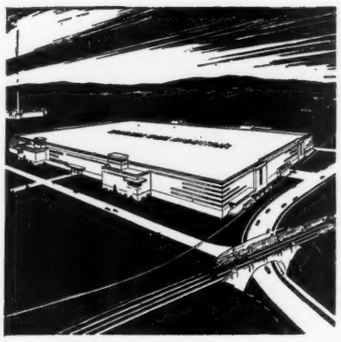
Courtesy S. F. Bowser and Company, Inc.

Fig. 6—The high pressure against which these force-feed systems will work insures the oil getting into the bearing. The cam and yoke principle of drive is employed.



Courtesy S. F. Bowser and Company, Inc.

Fig. 7—A single pump in this unit supplies the oil to several force pumps through individual adjustable sight feeds.



ON THE COVER

INDUSTRY'S first windowless factory building, as the designers picture it, is illustrated on the front cover of this issue. It is a $1,500,000 plant. The building embodies the application of many advanced ideas in the provision of extraordinary working conditions. The Simonds Saw & Steel Company is to erect the plant in Fitchburg, Mass., and the Austin Company, of Cleveland, Ohio, is responsible for design and erection.

The structure will cover nearly two city blocks and will have walls and roof without windows or skylights. Adequate systems will be installed for scientific lighting, ventilation, and noise absorption, making use of acoustical walls and ceilings and other means.

Every detail of the plant, from provision for manufactured weather to the use of orange-colored paint for machines, has been developed from biological and psychological studies involving the effects of workshop environment upon human efficiency. Experiments conducted by the company have indicated that an increase in efficiency by as much as 33 per cent may result from the new methods.

Two working shifts a day are planned, one from 5 a. m. to 2 p. m., the other from 2 p. m. to 11 p. m. All workers will get a chance to enjoy sunshine in the open during their hours off.

Lighting will be accomplished by means of 1,000-watt lamps mounted 18 ft. above the floor line and inclosed in special, steel, diffusing shades, giving a uniform light intensity of 20 foot-candles on the working plane. If power fails, an emergency lighting system, operated by storage batteries, will be thrown on automatically.

The lighting system providing one sheet of light of equal intensity over the entire building is expected to make it easier to achieve uniform quality of product. A small percentage of light from the lamps will be reflected to the ceiling for the purpose of creating a more cheerful atmosphere in the building and assisting in the general diffusion of light.

By means of automatic humidity control the moisture content of the air will be kept at the point most beneficial to comfort and health. Temperature will be controlled, and every ten minutes over 500,000 cu. ft. of air, tempered and cleansed of dust and other outdoor impurities by washing and filtering, will be brought into the building, making a complete change in that period of time.

Equipment is to be of such capacity as to produce a guaranteed maximum temperature, inside the plant, of not more than 16 deg. F. above the outside wet bulb temperature during the summer months. This will insure a maximum 60 per cent relative humidity which is within the comfort zone and, in general, maintain a temperature of from 5 to 10 deg. below the outside temperature during extremely hot, dry weather. No system involving refrigeration is contemplated at present. Ventilating ducts will be carried through the trusses and partial recirculation will be employed.

In hot weather the air will be cooled through evaporation by an atomized spray bank. In cold weather the air will be heated by means of coils in auxiliary fan houses through which the air will pass after washing. The air will be delivered to various sections of the building through ducts. The heating system will be under thermostatic control. Fumes, gases, exhausts, and excess heat will be removed from the building by underground ducts.

Special study has been given to the problem of eliminating drafts, and air will be delivered so that employees will feel only the freshness of a slowly moving body of air.

In order to lessen the nervous tension and distractions incident to modern factory din, extensive studies have been made in search of a solution of the problem of noise reduction. The result is to be accomplished by means of acoustical walls, ceiling, and floor; the isolation and padding of large machines and drop hammers; and by actual silencing processes.

Floors will have a concrete base with acoustical wood block for portions not occupied by equipment foundations. The concrete base is to be reinforced where fill is 2 ft. or more. Machinery causing noise and vibration will be isolated from the body of the floor and cushioned with cork pads. Noises from material in process of manufacture will be reduced by masking, tempering, and dampening.

Like the walls, the roof of the building is solid, being of metal with acoustical properties. The first layer is a metal acoustical holorib, a structurally strong perforated metal roof deck to permit the passage of sound to the insulation. Above this is a 1¼-in. layer of rock fiber bound with asphalt. Over this are two ½-in. layers of insulating board secured in asphalt. On top of this is a three-ply, built-up water-proofing.

The high insulating value of the walls and the roof will require relatively little heating capacity in the winter. In the summer this unusual insulation will be an advantage in excluding heat from the sun; but the ventilating system will be required to expel excess heat generated in the building. It will also help to reduce the humidity below that of the outside air insofar as is practicable without the use of refrigeration.

Walls will be acoustical cinder block with a facing of brick for architectural effect. It is expected that the building will absorb at least 60 per cent of the usual sounds. Due to the acoustical arrangements it will be possible to locate the plant office at one unpartitioned end of the building.

The plant will embody the latest results of psychological research into the effects of color in depressing or energizing human beings. Colors for the interior have been selected with a view toward attaining the best possible reaction from workmen, tending to keep them in a cheerful and active frame of mind while employed. Blue, green, and white will be used for walls and ceiling. The blue will reflect certain ultra-violet rays from

(Please turn to page 570)

QUESTIONS *and* ANSWERS

Please submit answers promptly. We expect to publish no answers later than the second issue following the appearance of the question. Selection will be made on the basis of quality, but answers first received have the best chance of being used.

How Remove Fumes from Plating Tanks?

We are having trouble with the fumes and steam from our plating department. The tanks were formerly in a separate room, but are now in one corner of a large space used for manufacturing and assembly operations. The six plating and cleaning tanks are 10 ft. long, 3 ft. wide, and about 3½ ft. high. A hood slightly larger than the tank is suspended 4 ft. above each tank. These hoods, which are shaped somewhat like an inverted V, are connected to a large duct from which the fumes are exhausted by a fan. The acid-dip vats are grouped under a separate and somewhat larger hood. When the plating room was off by itself the workmen in it did not mind such fumes as escaped, but now the employees in the other departments are complaining. Can we alter the present system to remove the fumes more effectively, or will it be necessary to install a new system? If a new one is required, how should it be arranged?

Milwaukee, Wis. **F. J. N.**

Making Form-Wound Coils Without Winding Machine

I should like to know the methods other readers use in making form-wound armature and stator coils when a winding and forming machine is not available. Is there any simple way of making such coils?

Marysville, Calif. **J. H. J.**

Power Factor Rating of Synchronous Motors

I have been investigating the use of synchronous motors to improve our plant power factor, and have been somewhat puzzled by the fact that these motors may be rated 80, 90, or 100 per cent power factor. It will be very helpful to me if someone will explain just what this rating means and how it affects the choice of synchronous motors for power factor correction. If we decide to buy such a motor, how can I tell whether to use, say, an 80 per cent, or a 100 per cent power factor machine?

Baltimore, Md. **B. G.**

Voltage Will Not Build Up on Generator

A puzzling case of trouble has developed on a 35-kw., 115-volt, compound-wound, d.c. generator. The commutator bars became loose and the armature was sent out for repairs, although the generator ran satisfactorily except for considerable sparking during heavy loads and rapid wear of the brushes.

When the generator was reassembled after repairs had been made we checked all connections, but the voltage failed to build up. On the possibility that the fields had lost their magnetism, we charged them with a 6-volt battery, without result. By exciting from an outside source we are able to light only two 60-watt lamps. Will someone kindly tell me the probable cause of our trouble and how to locate it?

Huron, S. D. **B. H.**

REGARDING the question by B. H., I would, first, test each field circuit separately with a Megger (not a magneto) for both grounds and open circuit. Test the repaired armature on a growler for shorts, open circuits, and reversed leads and then test it for possible grounds. Likewise, test the brush-holders for grounds and shorts. Of course, both field circuits should be tested separately for polarity with a compass. After assembly, check the brush setting for commutation. The bars to which the coil leads are connected should commutate or pass under the brush when the coil sides lie midway between a north and a south pole.

If all of the above tests show the proper condition, B. H. should again connect up his 6-volt battery to the generator and while this current is passing tap the frame at the places where the field poles are bolted to it, with a good-sized hammer. Perhaps 6 volts is too low for remagnetizing: he may have to use a 32-volt current.

The reason for this hammering is as follows: According to theory, all magnets are composed of a mass of tiny magnets. That is, each molecule or particle of the iron polepiece is itself a tiny magnet with a north and a south pole. When these tiny particles lie in a more or less regular order, with the north poles pointing one way and the south poles the other, the magnet is said to be charged. Sometimes these molecules become disarranged and the pole must be remagnetized with the help of an external current.

Denver, Colo. CARL A. WAGNER.

Is the Distance Between Centers Suitable for This Drive?

Plans have been made to install a 150-hp., 580-r.p.m. motor carrying a pulley 24 in. in diameter to drive a lineshaft at 278 r.p.m. A 50-in. pulley will be used on the lineshaft, and we will use a composition belt ⅜ in. thick and 18 in. wide. As now specified, the center distance between the motor shaft and lineshaft is 12 ft. 6 in., which I feel is too short for a drive of this size. If I am correct in this, what is the minimum center distance that would be satisfactory? As our space is limited, it may not be possible to use the desirable center distance. In that event, what would readers suggest as the most suitable type of drive?

Newark, N. J. **L. W.**

REPLYING to the question by L. W., the center distance is not too small for this drive. Distance and arcs of contact are ample for a high-grade leather belt running on the proper pulleys. L. W. does not state whether the drive is horizontal or vertical. I am assuming that it is horizontal and is pulling a steady load.

If it is a vertical drive I would use a first-class, two-ply, special-mineral-tanned leather belt 18 in. wide and a wrapper pulley.

According to my figures, the belt will run at a speed of 3,640 ft. per min. An 18-in. double, oak-tanned leather belt of the highest quality, on a horizontal drive, will transmit 150

hp. on the centers named by L. W. However, to be certain that there will be no slip, I would use a special-tanned leather belt because those belts have a very high coefficient of friction.

If it is a vertical drive, or if it slopes 45 deg. or more with the horizontal, I would use the best belt obtainable and a wrapper pulley.

Newark, N. J. W. F. SCHAPHORST.

What Causes Poor Starting of This Motor?

We have a G. E., 30-hp., 220-volt, 900-r.p.m., Type K2-10A, Form K, wound-rotor motor from which we removed the slip-rings and shorted the slipring connections. We now find that sometimes the motor will not start until the rotor is moved slightly. When the rotor is not on this particular spot the motor will start and when it comes up to speed the pulling power is normal. We have tested for shorts and grounds and could not find these or any other defects. Can any readers tell me the cause and remedy for this condition?

Logan, W. Va. B. S.

IN answer to B. S., a low-resistance rotor in a phase-wound induction motor will develop poor torque, especially in certain positions, where the ratio of the number of slots in the rotor to those in the stator, and the shape of the teeth, are such as to accomodate considerable leakage flux.

In short circuiting the collector rings the rotor resistance has been reduced to a minimum. At the instant of starting, the density is lowest and the current highest in both rotor and stator. At no-load synchronous speed the density is highest and the current lowest. It is evident from this that the power factor is at its poorest at no-load synchronous speed, due to the maximum reactance. However, the power factor will not be considered here.

The rotor acts similarly to a transformer secondary in opposing the flux. Obviously, the lower the resistance in the secondary, the higher the current and the lower the starting torque, especially at certain positions where the rotor and stator tooth alignments are most favorable for leakage flux. This leakage is maximum, when the rotor current is maximum, as it opposes the flux traversing its normal magnetic path and diverts it through leakage circuits wherever the reluctance permits.

Although the leakage flux is not active in producing watts in the secondary, it does act to cause counter-e.m.f. in the primary.

Inserting resistance in the rotor winding decreases the rotor current, thereby lessening the opposing effect and permitting a higher magnetic density in the normal magnetic path. This higher density in turn increases the counter-e.m.f. in the primary. The primary starting current is thus decreased; the torque is also improved by the higher magnetic density, and will continue to increase as resistance is added until the resistance and reactance are equal. When this condition is reached the torque is maximum. From this point the torque decreases as resistance is added. Naturally, the leakage flux is not so great when resistance is inserted in the secondary for the secondary current which causes it has been reduced.

It has been my experience to encounter and remedy dead points in rotors on several occasions. In some cases the rotor winding on the connection end was short circuited by bolting copper rings to the top and bottom of the clips, giving an effect similar to a squirrel cage. This procedure eliminates the fixed polar winding, permits each coil to act independently of all others, distributes the counter-action of the secondary, and removes the dead points. In other words, the secondary pole is no longer in a fixed position and in series with other poles of the same phase. No matter in what position the rotor rests, the relative position of the poles assumed in the winding to those of the stator, will be the same.

It may at first appear that the sectional area of the rings, or their resistance, is an important factor; but when it is realized that even were the rings of zero resistance the winding would retain the same resistance per volt as before, it is evident that the only consideration need be given the rings is to see that they are of sufficient area to carry the current without excessive heat loss, and are of convenient size for mechanical assembly.

In a squirrel-cage machine with short, straight rotor bars the resistance of the ring is of greater importance, for the percentage of the circuit which the rings include is much greater.

The most recent case in my experience involved a 2,200-volt, 350-hp., 600-r.p.m. motor of the internal variable-resistance type. The resistance had been removed and it was necessary to start the machine with a bar. For mechanical reasons it was not practicable to use a short-circuiting ring as above described, owing to the extreme narrowness and depth of the clips. However, by removing all clips, swinging the coil ends and reconnecting so that each coil was a closed and independent circuit in itself, the desired results were obtained.

As mentioned above, inserting resistance in the rotor circuit will also eliminate the dead points, but unless the resistance can be removed after starting the performance will be poor, the slippage will be high and the speed may be too far below normal to drive the load properly.

The above schemes will also permit emergency speed changes in wound-rotor machines, necessitating of course, the use of a primary current-decreasing device. The short-circuiting ring can be removed after the motor has served its purpose, and no winding connections in the rotor have been disturbed.

San Francisco, Calif. W. O. HURLBUT.

REPLYING to B. S.'s question, I recommend that he place the rotor in a lathe and remove the insulation from the top side of the coils for about 2½ in. back from the coil clips. Clean the bare part of the coils and with a heavy soldering iron tin the tops. Next, apply about twenty turns of No. 14 banding wire under heavy tension onto the tinned surface of the rotor winding, using a liberal supply of clips under the banding wire. After the banding wire is securely in place do a good soldering job.

B. S. should discard his slipring starting equipment and use a compensator. It may be necessary to use higher voltage taps on the transformer if the motor has to start a heavy load.

A. H. MOORE.

The Electrical Supply Company, Johnson City, Tenn.

Placing Primary and Secondary Circuits for Motor in One Conduit

A question has come up regarding the advisability of placing both the primary and secondary circuits for a 100-hp., 440-volt, 60-cycle, three-phase, wound-rotor induction motor in one conduit. I should like to know whether it is safe to do this and whether it is considered good or bad practice. Why?

McComas, W. Va. E. R. L.

THERE is no objection to E. R. L. placing both circuits in one conduit except the practical one of the size of the conduit required. Generally, however, the circuits are run in separate conduits, particularly in the case of a low-voltage motor of the rating given. C. O. VON DANNENBERG.

New York, N. Y.

IN reply to E. R. L., it is not only against Code rules to install both primary and secondary circuits in the same conduit but it is unsafe because of the tendency of the cables to heat up, due to induction.

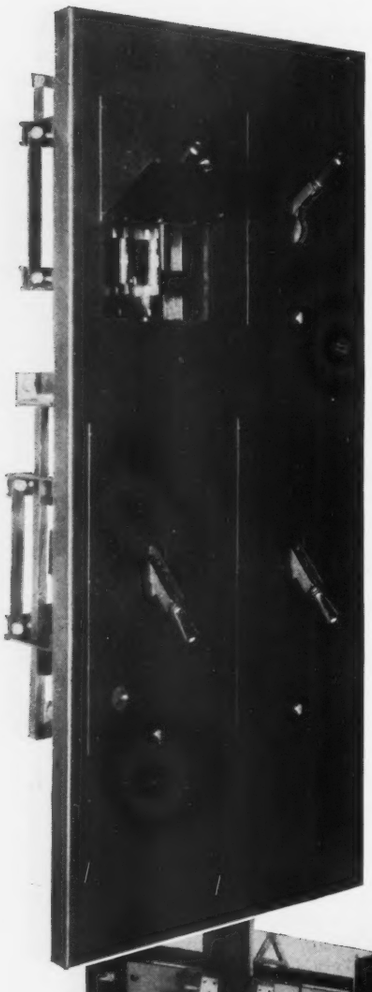
Ludlow, Mass. THEODORE M. SMALL.

Editor's Note

(The above answer's to E.R.L.'s question indicate a difference of opinion regarding the application of the rule in Art. 5, Sec. 503, paragraph n of the National Electrical Code to the case in point. The Editors will be glad to know of any instances in which a definite ruling has been made on the question of placing the primary and secondary circuits for a wound-rotor motor in one conduit.)

Control Boards for Industrial Service

By B. J. AUBURN
Control Engineering Department
Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.



PROGRESS in the design of control boards goes by leaps and bounds; hence, it is the purpose of this article to point out the things to look for when selecting and installing a new control board.

In the selection of a new board there are several points to be considered. Initial cost may be the determining factor in some cases, but usually continuity of service is of prime importance and must be provided regardless of cost. This is especially true in almost all industrial plants where shutdowns, even for a short period, are costly. No equipment should be considered too good for industrial application. The maximum degree of safety that can be obtained is another important item. These and such other considerations as type of equipment controlled, space, capacity of the plant, and so on, govern the selection of control equipment.

Fig. 1—A dead-front board with manually operated breakers mounted at the rear.

Fig. 2—Typical d.c. board with carbon circuit breakers and contactors mounted in front. Fig. 3 shows a rear view of this board.

Industrial control boards may be divided into three distinct classes depending on the type of equipment used and the method of operation, as follows:

1. A.c. boards for control of the a.c. motors and feeders.
2. D.c. boards for control of d.c. motors and generators.
3. A.c.-d.c. boards where both types of motors are used.

Each of these classes again can be subdivided into two groups: those with manually operated oil or carbon circuit breakers, and those with electrically operated oil circuit breakers controlled from the board, or with electrically operated carbon breakers or contactors controlled from one central station location in the plant, or from push-button stations located at the motors.

The factor of safety desired in a

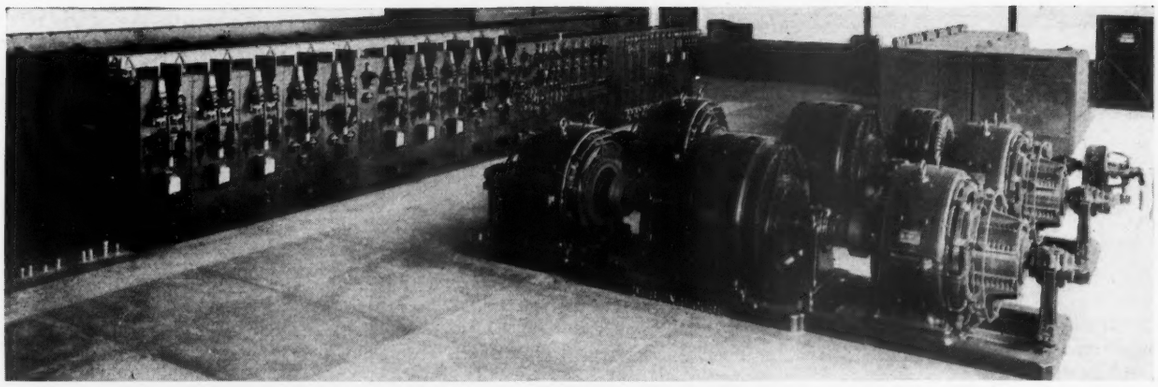


Fig. 4—Adequate provision has been made for future additions to this substation. Note the spare conduits at the left, for new panels.

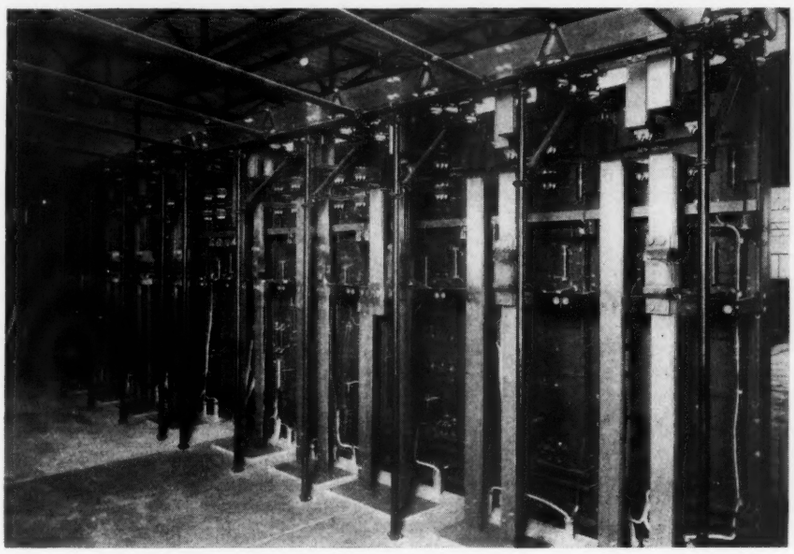


Fig. 3—Arrangement of bus copper and control wiring at the rear of the board shown in Fig. 2.

control board depends largely on its type. The a.c. board can readily be made of the dead-front type, where manually or electrically operated oil circuit breakers are used. For this type, steel panels are used extensively at present in preference to the slate or ebony panel. This type of board is very desirable in small plants where the operator is often not an electrical man.

The d.c. and a.c. control boards on which carbon breakers are used can not well be adapted to a dead-front, steel-panel construction: live-front slate or ebony panels must be used for the breakers, contactors, and knife switches used in controlling the motors.

In Fig. 1 is shown a dead-front board with manually operated breakers mounted immediately in the rear. Fig. 2 shows a typical d.c. board with carbon breakers and contactors mounted in front of the board, with the copper bus in the rear, as Fig. 3 shows.

The number and order of panels in the control board and their location with respect to the equipment controlled are always of major importance. It is important to locate the panels so that copper bus, if used, is reduced to a minimum and used to the best advantage, as well as cable and conduit runs to the machines controlled. Considerable saving in money, time, and space will result if all or the majority of conduit, cable, and copper bus crossings are eliminated.

It is always well to locate control boards so that there is ample room for expansion later on. With the use of electric power in industrial plants expanding so rapidly, it is often found that as soon as the control board is installed the load requirements have increased considerably, necessitating additional feeder panels.

The common cry of the electrical engineers in the plant of today is lack of space. The electrical engineer should always insist on plenty of room in his substation, for future expansion. It is advisable, too, to make provision for future equipment of special character, or the addition of special metering and control equipment. Fig. 4 shows a well-laid-out substation with provision for future equipment.

In all cases where complicated control equipment is involved it is good practice to bring the electrical manufacturer, construction design engineer, and machine builder together to discuss the problem thoroughly.

Fig. 5 represents a typical layout of a motor-generator substation for an average industrial plant, where there are a few motors in the substation and a number scattered around the plant, driving pumps, fans, blowers, grinders, etc. The control board, motor-generator set, and motors are located so as to effect the maximum saving of bus copper and cable, at the same time keeping the sequence of panels in the most logical order.

In a substation of this type there is a natural subdivision of the a.c. and d.c. power used. Let us locate the d.c. on the left and the a.c. on the right, and we will have the following layout:

1. Incoming line panel
2. Synchronous motor starting panel
3. Auxiliary power transformer (a.c. motors in the plant)
4. and 5. A.c. distribution panels
6. Plant lighting transformer
7. D.c. generator (auxiliary power and excitation)
8, 9 and 10. D.c. distribution feeder panels
11 to 15. D.c. motors
16. D.c. generators
17 to 20. D.c. feeders (to separate motors or groups in the plant)

Note that the control board is lo-

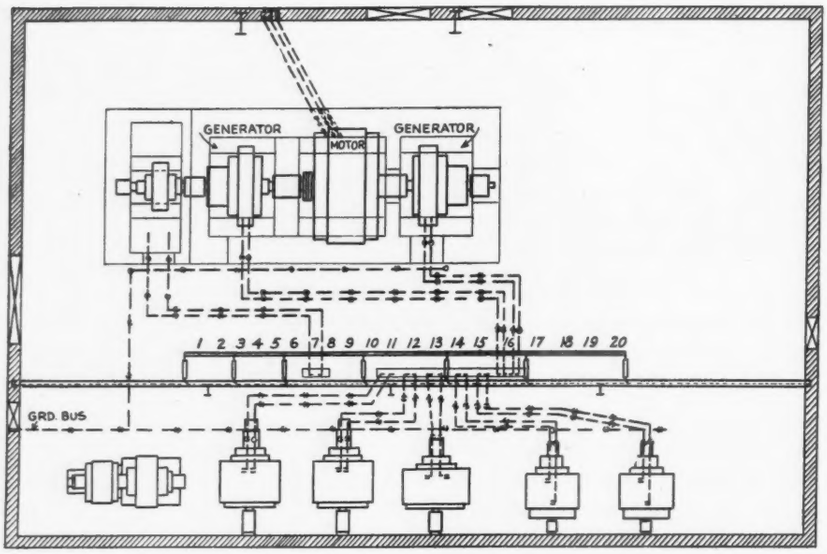


Fig. 5—This industrial motor-generator substation was laid out to secure the most effective use of bus copper and cable, and give an orderly arrangement.

cated so as to permit a good walking aisle in the rear for regular inspection or repairs to the equipment.

In Fig. 6 is shown a typical a.c. substation with remote-controlled oil circuit breakers. Again the board and equipment are so arranged as to permit the utmost economy in cable runs, control wiring, and conduit layout; however, the arrangement of panels and motors permits very easy orientation by the average operator.

On control boards of this type the tendency is towards dead-front, steel-panel construction. Devices not suitable for mounting on a steel panel, such as field contactors, are usually mounted on a small slab back of the panels. Where induction motors only are employed and no contactors are used steel panel construction can readily be used.

Control board panels are shipped complete with pipe or angle-iron supporting frame. The channel base upon which panels are lined up should be properly leveled, securely bolted to the floor, and grouted. The base is provided with one hole located in the middle of each panel for grouting. With average-sized boards consisting of ten or more panels, the middle panel should be erected first, and the remainder of the panels built up on both sides to insure a proper line-up. The control board is usually braced to the wall directly, or to channel irons fastened to the building columns. All fittings for such bracing, with the exception of pipe, are supplied with the board.

It is always good practice to erect a grillework at the sides of the board with a door at one or both ends. The screen prevents the access of unauthorized persons to the back of the board, and the undesirable use of this space as a storage space.

Copper Bus

After the panels are erected and securely braced the bus copper can be installed and cable and copper feeder connections made. The copper for the bus back of the board and the connections from the bus to the breaker and knife switch studs is bent to shape at the factory, permitting erection of these items with minimum expense and trouble. The copper bus is usually supported by the wall braces. Fig. 3 shows a typical panel with copper connections on the back.

The copper is brought at the factory from the breaker studs to a support located from 12 to 36 in. from the floor. If a cable feeder to a motor is used, terminals of the proper capacity are usually furnished with the panel at this point. If copper is used the connection from this point is made in the field and the proper opening is provided in the floor for carrying the feeder through. This opening is closed with a thin slab of asbestos or Transite after the copper has been installed. Copper in the basement is carried on bus supports resting on a pipe structure suspended from the basement ceiling. The present tendency is to inclose all copper runs in the basement with a screen, especially when the ceiling is low.

The control cable is brought to the back of the board in conduits rising about 6 in. above the floor level near the terminal blocks upon which the wiring from the panels is ended.

The methods of closing conduits are many, and vary with the type of service, control cable used, and personal preference. Lead-covered cable is terminated sometimes in potheads which permit sealing of the conduit completely. In the majority of cases, however, a plain conduit bushing is used.

If possible, a basement should always be provided for the substation, or at least under the control board. This type of construction, although costly, permits of the best layout. The basement can be used very advantageously for locating the battery, rheostats, starting resistors, and so on, as well as the bus and cable runs.

Control cable conduits are buried in the concrete floor. With careful design each conduit can be terminated at the proper spot and the use of any

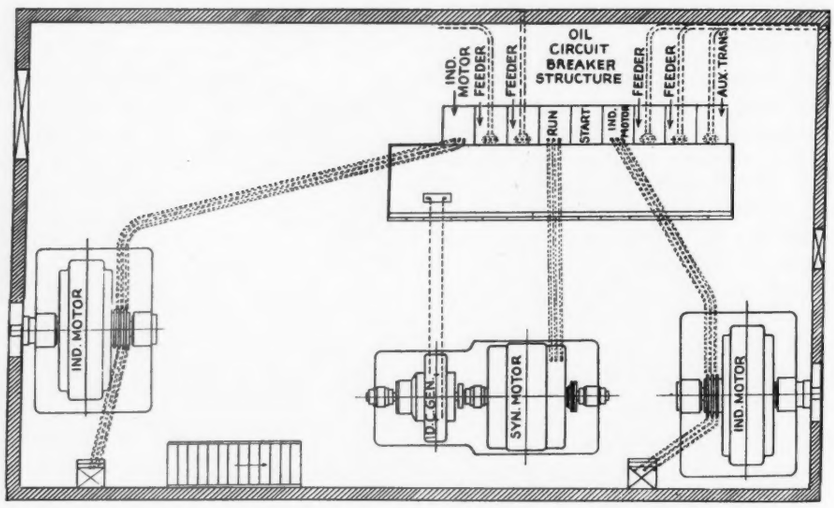


Fig. 6—Typical a.c substation using remote-controlled oil circuit breakers.

kind of trough back of the control board for distributing control cable to panels can be avoided. The use of control cable trough is favored in some installations, but it is usually better to avoid its use.

Selection of proper metering and control equipment for industrial control boards depends largely on the class of service and the amount of protection desired. A safe rule to follow is not to use any apparatus that is not actually necessary for safe operation. There is a marked tendency at times to duplicate certain type of instruments and not make any provisions for others.

An indicating ammeter and a graphic or integrating watt-hour meter will suffice for any d.c. motor circuit. At the operator's control desk or panel a speed indicator is usually the only instrument actually used.

On a synchronous motor circuit a large number of instruments is required. An indicating, integrating, or curve-drawing wattmeter is always used, as well as an ammeter for the field circuit. It is a question whether a power factor meter or reactive volt-ampere meter, if used, is preferable on the motor circuit. The tendency at present is towards the latter.

So far as control equipment is concerned, ease of operation and reliability should always be the goal. If certain operations can be performed by one control or master switch, instead of two or three, it should be used. A good illustration is the forward and reverse switches on an induction motor control. One switch can be used to advantage, but two switches are always provided and many a time an operator, just for curiosity or in plain ignorance, will operate both switches at once. Interlocks, positive as they are today, fail sometimes and the result is a dead short on the bus.

Protective equipment should be given very careful study. It is not possible to discuss this subject at length here, but a few remarks are necessary. Overload protection is always supplied, and is standard with all apparatus. Open-phase or reverse-phase protection is gaining favor on the a.c. applications. Field failure and overspeed protection should always be provided. On a large, slow-speed synchronous motor driving industrial machinery differential protection against internal faults is always to be recommended. Low-voltage protection is always desirable and almost universally used. Temperature protection and bearing thermostats are always desirable on large machines.

How Control Non-Productive Costs?

By HARRY W. BENTON
Plant Engineer, The Pratt & Whitney Company
Hartford, Conn.

THERE are, generally speaking, two classifications of cost ordinarily used in industry, namely, Productive and Non-Productive. Different manufacturers and cost departments have different titles for these costs, sometimes calling them direct and indirect. However, productive and non-productive are terms more readily understood by the average mind.

It has always been particularly difficult to control non-productive, but comparatively easy to control productive costs. In this article I use these definitions: The cost of all labor and materials which enter directly into and become a part of the finished product is *Productive* cost. The cost of all other labor and materials, regardless of what they may be, is *Non-Productive* cost.

There are many elements of non-productive cost that are non-controllable. Some of the major ones are lighting, heating, sanitation, electric power, fire protection.

It is well understood that production is retarded by poor lighting and it is equally well-known that there is a reasonable and economical cost for good lighting, so that this item may be varied somewhat, but if it is varied in the direction of poor lighting, then productive costs must be increased because of the lowered rate of production. The same condition can develop if a manufacturing plant is insufficiently heated.

We can also take into consideration such items as taxes and compensation insurance (in fact, all classes of insurance); transportation costs; and telephone and telegraphic expenses. We could, perhaps, enlarge considerably upon this list of what might honestly be considered or classified as uncontrollable non-productive expense.

We might at this time consider raw materials passing through the average plant in the various processes of manufacture and finally arriving at the shipping department as a finished product. Only productive time has been used in changing the raw material into finished product. The amount of productive time varies directly with the rate of production and when production quantities rise or fall a corresponding rise or fall occurs in the amount of productive labor on the payroll.

This productive labor is actually the sole source of income to the industry and, with this thought in mind, we can see plainly that each hour of productive time must carry its share of all burden, or overhead, or non-productive expense. Therefore, if the non-productive expense is not kept within the amount which the productive labor is able to carry and, at the same time show a margin of profit, there can be no profit; but if the non-productive expense can be kept within the specified amount, regardless of variations in the rate of production, then each and every hour of shop operating time will turn into the management a known amount of profit.

It is because managements have been unable to maintain this balance of non-productive and productive time that various methods of supervision of non-productive time have been developed and tried and the method which I wish briefly to bring to the attention of the readers at this time is a budget method of control which has worked with remarkable success for a period of more than five years and which has provided the management with a measuring stick that foretells accurately what will be

the balance sheet figures before the month is very far advanced.

Taking productive time instead of money as the basis of comparison, it is easy to develop a set of percentages for the control of all non-productive labor and non-productive supplies; in fact, for the control of every item of industrial procedure. When this method was established in the shop which I have in mind, the cost office had investigated every classification of cost as shown by the departmental records for two years and had developed a set of percentages for the government or control of these various costs.

These percentages were given to the departmental heads after several weekly meetings of one hour each, during which the foremen were well instructed on the principle involved and the use of the figures. By this method each foreman made a check each morning of the number of productive men working in his department. This, multiplied by the hours per day, governed the probable productive hours in his department for that day. With that figure as a basis, and by the use of the ratio figures given, he readily calculated how many non-productive hours he was permitted to have.

He also made a calculation as to how much money he could spend that day for departmental supplies because he was given an allowance of so many cents for each productive hour. With regard to departmental supplies, at the end of each week the cost office gave the foreman a statement as to what his actual cost had been for the week just ended and if the actual figures were in excess of the foreman's estimated figures, developed from the number of productive hours as previously stated, he realized he had purchased too many supplies.

By a similar method, the amount of time rendered to the productive department by the tool department was measured and controlled on the basis of so many hours of tool room service per one hundred hours of departmental productive time. Maintenance of power transmission equipment was scheduled in the same way.

Let us take the master mechanic's or plant engineer's division, which is one of the largest non-productive departments in most plants. The amount of non-productive labor carried in this department was set at 14.7 hours for each one hundred hours of productive time throughout the plant. Thus, if the total productive hours per day happened to be 9,000, the plant engineer's department was allowed 1,323 hours.

If the number of men working in any one day in the plant engineer's department made a total time in excess of the above calculation, then the plant engineer knew his department was too heavy.

The supplies used by the plant engineer's department were scheduled on the basis of cents per departmental hour.

During the first year that this budget method of control was in operation in a plant in which the total number of men employed varied from 1,700 to 2,000, there resulted a saving in non-productive expense of over $200,000 and the entire time required for the calculation of the necessary figures on the part of each foreman was less than ten minutes daily.

The particularly satisfactory part of this method is the fact that each and every departmental foreman knows each morning before nine o'clock exactly how his department is performing and whether or not his costs for the day are within the schedule or beyond, and he knows just as surely that the management knows the same facts. Consequently, this makes it possible for the foreman to supervise his department *and to know that he is supervising it* and when his costs are in excess of what they should be, he immediately makes a trip to the superintendent and lays the cards on the table. Whatever may be the difficulty or the cause of the excess cost, the matter is given immediate attention.

It should be evident from a study of these statements that this method possesses the desirable probability, so to speak, of telling the money where to go before it is spent. The average method of supervision of non-productive expenses involves waiting until the month's records are totaled in the cost office and then, after the money has been spent and after the bad records have been made and written into the history of the plant, calling a meeting for the facts to be laid before the foremen. They are told how bad their performance has been and that conditions must be improved.

The reduction of non-productive costs and the control of these costs, so that they can at all times be maintained within the proper ratio to productive costs is, therefore, a matter of giving to the departmental foremen an easily applied rule or measuring stick wherewith they can govern departmental performance daily.

To my mind, it is highly necessary that the foremen of any industry be made to realize that they are the management and that the men at the head of the organization, who are ordinarily called general managers, are the men who lay down the policy, the principles and the rules by which the plant is to be governed; but the actual work of making application of these rules and principles is entrusted to the departmental heads; and that unless the management provides these men with a method that they can understand and apply it is next to useless for the management to expect results in the control of non-productive costs.

This subject, I believe, offers a very fertile field and I should like to see it discussed freely in the columns of this magazine for the benefit of all.

On The Cover

(Continued from page 563)

the lamps, green is the active or energizing component, and white is for the sensation of light and to reflect cleanliness.

Orange will be used for machines. The color was selected because it will lift the visibility of machine parts and aid in accident prevention.

The building will be of single-story construction with no partitions and only 56 columns. The reduction in the number of columns has saved much space.

Wash room facilities for employees are to be comparable with such facilities in skyscrapers. Floors and walls will be of white tile.

There are 54 acres of land available to insure for future expansion. The new layout will be a consolidation of the present Chicago factory and two existing plants in Fitchburg. The building is approximately 360x 560 ft. The 360-ft. dimension is made up of nine 40-ft. spaces or bays, and the 560-ft. dimension is made up of eight 70-ft. aisles. On the outer side, on the quarter points of each of the longer dimensions, there will be two rooms 27x52 ft. long. These rooms will house ventilating equipment which will be placed overhead in case of expansion. A wet pipe automatic sprinkler system for an area of approximately 66,000 sq. ft. will be installed.

PLANT • ENGINEERS' • FORUM

* * *

Here is the fifteenth of a series of questions, each of which has at least two sides. A new question will be presented next month, and our readers' answers to previous questions also will be published. Write down your opinions and send them to the editor. Answers published will be paid for at an attractive rate.

* * *

Shall There Be a National Association of Maintenance Engineers?

Not so long ago George Shipman promised to visit Frank Fulleger at his plant to see what had been done by way of maintenance and plant rehabilitation during depression. George has just concluded his round of inspection and the two men are seated in Frank's office in the plant.

* * *

"A peach of a job, Frank—and it gives strength to a pet idea that I've had for a long time."

"An idea? Don't let it get away! Might be better if you'd pass it on so it will still exist if you happen to have a serious argument with traffic."

"I don't mind, Frank. There's nothing that I can patent. It's just this: 'You've done something here; you've told me about it and you'll tell some of your friends. I'll tell a half-dozen people. But suppose you could tell every maintenance engineer—every plant engineer—in the country. Then don't forget that you're not the only fellow who has had bright ideas—even this idea. And it has been proved that industry as a whole has advanced in direct proportion to the extent of the interchange of ideas and information concerning plant practices. Now suppose you could give an illustrated talk this fall before the National Association of Maintenance Engineers——' "

"Never heard of it," interrupted Frank.

"Of course you didn't—that's what I'm getting at. There isn't any such association. But suppose there were——"

"I see. Say, at the meetings I might have picked up ready-made some of the plans that I've worked out the past few years."

"That you might, Frank. If you hadn't willingly picked them up they would have stuck to you anyway, I guess. Pretty hard to expose yourself to germs, you know, without having them attach themselves to you—no matter whether they are disease germs or idea germs."

"Seems to me, George, there was some consideration given the formation of such an organization last summer."

"Right. Certain electrical maintenance men got together at Cedar Point, Ohio, and figured on it, but any definite action was postponed. And they were only electrical men. If they do organize it will be a starter, but maintenance is a three-headed animal. I can't help feeling that the ultimate association will take in the three heads—electrical, mechanical, and building maintenance. You know it's just impossible to split a Siamese twin—how much harder it would be with a triplet anatomy."

"Be a good thing for the railroads and hotels, George. And of course our companies would have to foot the bills."

"Traveling expenses, yes. But that's not a terribly expensive way of buying ideas. You'd probably pay your own dues each year. But that's getting down to details. There are plenty of hurdles to be taken in forming an association—don't forget that. The first thing to do is to sound out some maintenance engineers."

* * *

And there, of course, is where INDUSTRIAL ENGINEERING *steps in. It offers you maintenance engineers, you plant engineers—its readers—the opportunity to support or decry this suggestion of George Shipman concerning the formation of an organization of maintenance engineers.*

Is the formation of a National Association of Maintenance Engineers desirable?

Is it feasible?

What local organizations exist that might form the nucleus of a National organization?

(Answers to previous questions start on the following page)

READERS' ANSWERS

to previous questions

Who Shall Specify Equipment?

(Question presented in the October issue)

BY all means, the man responsible for the proper operation, upkeep, maintenance, and service of plant apparatus should specify equipment. Long, economical service under peak production conditions should govern the plant engineer's or operating superintendent's choice of equipment. He should not lose sight of the fact that cost, while not the most important requisite, is always a factor to be considered.

Often the purchasing agent is qualified to offer advice on an alternate piece of equipment which is just as good for the purpose and cheaper in cost. However, he should not specify something different from the original specifications without first consulting the plant engineer. If these two cannot agree the manager should be arbiter when he signs the requisition.

Operating superintendents or engineers are better qualified than other individuals to specify equipment because of their close contact with it under operating conditions.

Although the purchasing agent has a broad knowledge of products and markets and can usually give sound advice which may aid in selecting equipment of the same economical qualities at a saving in cost, his should be an advisory capacity with the plant engineer definitely specifying the equipment needed.

E. M. DETWILER, *Plant Engineer*
Worthington Pump and Machinery Corporation
Buffalo, N. Y.

WHERE a large number of requisitions go through without specifying any particular make of material or equipment the purchasing agent should buy at the best price obtainable.

But where a requisition specifies a particular make of equipment the purchasing agent should first ascertain its price and then obtain comparative prices on similar equipment made by other manufacturers.

Next, he should submit the various prices to the originator of the requisition, and then abide by the decision of the originator who must use the equipment. No doubt, he knows better than the purchasing agent what is the best to use.

J. WALTER WRIGHT, *Assistant to the President*
Wilmot Fleming Iron & Steel Company
Philadelphia, Pa.

ALMOST all plant engineers have been confronted with the problem of a purchasing agent who pares down specifications to secure a better price. Sometimes it is detrimental to the plant, but more often it is a benefit to all concerned. The plant engineer then has the opportunity to present his case for the desired article. Unless he can show the benefit to the plant that would come from his specifications, he does not deserve attention. Does he?

There is one thing some purchasing agents do that I believe is utterly inexcusable. That is to revise specifications and order material without advising the plant engineer of the change and the reasons for doing so before sending out the order.

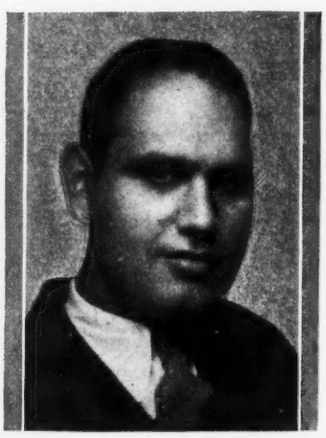
I believe that men with the broader view of modern industry are striving to learn, at least, the fundamentals of the other man's position. The plant engineer should learn why the purchasing agent believes certain economies are necessary, and conversely, the purchasing agent should take an occasional trip through the plant and see why the engineer demands sterling quality in his equipment.

CARL A. WAGNER
Chief of Electrical Service and Sales
General Machinery and Supply Company
Denver, Colo.

BUYING of material should be under the control of the purchasing department. The duties of the foremen and department heads are or should be confined to production, whereas the purchasing department should be concerned only with the procurement of the material or equipment.

A fault in permitting department heads to requisition material is that such men, concerned primarily with production, have not, as a rule, sufficient general knowledge of market conditions to acquaint them with the possibilities of using other materials, and of possible sources of supply to order intelligently. They are prone to develop a habit of ordering the same material or brand for which they have formed a preference while there may be, and probably is, some other material or brand that would be less costly and just as serviceable, and which may be in use in some other department.

Another fault of requisitioning material this way is that department heads tend to ignore specifications. If they specify qualities and properties, such specifications



HARRY KAUFMAN

Engineering Department, Naval Aircraft Factory, Philadelphia, Pa. His answer to last month's question starts immediately above.

will be based on incomplete knowledge, and the procurement of the best material will be an accident, rather than otherwise. In a well organized establishment a material-control department will be aided by a testing or engineering department which will develop such specifications for supplies as will insure the best materials for their purpose being procured.

Nobody denies that the shop should know the class of materials that can be machined the cheapest, or the cheapest type of equipment to buy. The purchasing department, however, should know where that material or equipment can be bought economically, and also have suggestions for other materials or equipment that might do.

If both the shop and purchasing agent are satisfied to try a new and cheaper material, its adoption should be passed upon by a third department as it may have a bad effect on future sales. The shop wants materials that will give it the least trouble; the purchasing department wants to make a showing on low material cost, while the salesmen and the directors want high qualities, low selling prices, and fair profits.

When the owner-manager took off his overalls and went into the office he functioned as the purchasing agent and was an ideal person to do it for he combined in himself the various departments referred to. But when he delegated his purchasing authority to someone else, his authority but not his wisdom went with it.

A direct answer to the question as to who shall designate the class and type of material and equipment to be purchased is, of course, neither of the two departments. They must do it together, with the aid of the engineering department to promulgate the specifications for the material or equipment, obtaining information from the shop pertinent to the best material or equipment to buy from shop standpoint, leaving the decision to the purchasing department to buy cheaply and according to specifications.

HARRY KAUFMAN, *Engineering Department*
Naval Aircraft Factory
Philadelphia, Pa.

What Maintenance Policy During Depression?

(Question presented in the September issue)

DURING slack times at our plant, we revise layout of the production lines and do all the changing for future business. The purchase of new equipment, installation, testing and tooling all can be done much more efficiently when the plant force is not being crowded.

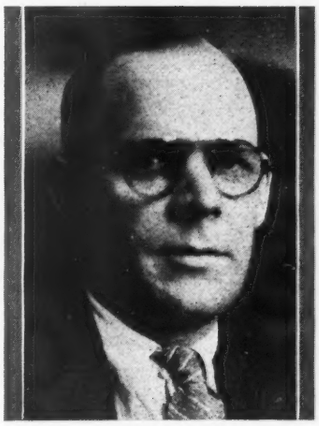
Plants that have seasonal trade have always used the slack season to build up stock and the plant in general. Faith in the product is the foundation of any plan for the future.

The maintenance staff must have, as its leader, an engineer or executive who can, in dull times, lay his plans for improvements before the management. To do this with any degree of success, he must know what new equipment the plant must have, where it can be purchased, its specifications, and how much it is going to save.

Lacking the finances, the credit, or the courage to take this step, the next best thing should be done. Make a survey of needed equipment, get orders and plans ready, and then break the records putting them into effect when it is possible to do so.

Remember that when you act now you are a buyer for some other manufacturer and that it was lack of buying that brought on dull times. If possible, invest in the future—buy now.

CHAS. H. WILLEY
Hoyt Electrical Works
Pennacook, N. H.



CHARLES R. WHITEHOUSE

Standards Engineer, The Holtzer-Cabot Electric Company, Boston, Mass. Mr. Whitehouse's views on "Maintenance During Depression" will be found in this column.

THIS is a question that is self-answerable to the big fellow, but to the smaller one it is serious. Certainly there is no better time to check up, replace and repair machinery than during a slack season. But with the shop running light it is a different problem, for when things are slack, the necessary money for repair work is slack also. However, even the smallest can have the maintenance department go over and repair the machinery and get it in good running condition, even though they cannot afford to make replacements.

In a production department it is a serious matter to repair or replace machinery during busy times. A two-day repair job may mean weeks of hard work to bring production up to schedule again. With this in mind, any right-minded owner will have all of this kind of work done in the slack period. Any man, or group of men, owning a manufacturing business, who sit back and let their maintenance problems slide during the slack season are riding toward a fall.

CHARLES R. WHITEHOUSE, *Standards Engineer*
The Holtzer-Cabot Electric Company
Boston, Mass.

USUALLY, business has been very good for several years prior to a depression and during this busy period many needed repairs have been postponed. Thus everything is favorable for an industrial plant to carry on an extensive construction and repair program during slack periods. Prices are down, men are readily available, the plant needs considerable overhauling, and construction work will not interfere with production.

After an industrial depression ends, the markets are eager for goods and the plant that has modern, reliable equipment ready to start active production will get the cream of the orders. Without overhauling its machinery during periods of depression, a plant is not in con-

dition to produce goods at a low cost and in large quantities.

Each plant, before deciding on an extensive construction program, must be in financial condition to stand the expense. It requires a shrewd manager to be able to judge just how much should be spent. It is also difficult to guess how long the depression will last and how severe it will be. It seems, however, that periods of depression are constantly growing shorter and less severe. A number of large corporations starting large construction programs at the same time tends to end the period of depression more rapidly than if everyone hangs back and takes the attitude—"Let George do it."

CHAS. A. PETERSON, *Master Mechanic*
Cold Spring Granite Company
Cold Spring, Minn.

Do Centralized or Decentralized Stores Better Serve Maintenance?

(Question presented in the August issue)

UNDOUBTEDLY Frank's opinion of the centralized storeroom was a snap judgment. Now his snap judgment would not be questioned had he been on his new job a sufficient time to obtain a larger view of his new department's place in the scheme of the entire plant. He was nettled by this upset in his plan to repair the stoker. This is a common fault of all of us—to place the blame on some other department when each of us shares a contingent responsibility.

Analyzing Frank's reaction from another angle and setting up the premise that Frank has been made general superintendent of the plant instead of head of plant maintenance, without question Frank's initial reaction would not be to condemn the existing system. There would be nothing in the situation from his standpoint to suggest such a radical move. His reaction, and the one suggested by the experience of many industrial plants, would be to inquire where the perpetual inventory had become in error and take effective measures to prevent recurrence.

The problem faced by Frank is not a new one nor is it rare. Sometimes the situation arises from the fact that the system known as the perpetual inventory card record is taken too literally. Certain stocks must have a physical inventory made at regular intervals and the cards corrected accordingly. Does this requirement affect the value of the perpetual inventory system? It does not. The point is that an actual check should be made at intervals short enough so that normally the stocks will not be depleted before the minimum quantity is used. The errors may come about by mistakes in counting or by loss of requisitions or by neglect to issue requisitions where the supplies are not in the main storeroom served by counter clerks.

Returning to the contingent responsibility of the department using the material, we find that the high-grade foreman co-operates with the storekeeper and they walk through the stockrooms and discuss personally the situation concerning the departmental supplies. This should be done at least once a month. Both men will become familiar with the stock and when any equipment begins to show signs of wear the stock will be specially checked for items for the machine in question. Likewise, when new equipment is added, space will be provided for a new lot of parts and requisitions will be placed.

There must be highly specialized reasons for considering departmental storekeeping.

J. ELMER HOUSLEY, *Electrical Superintendent*
Aluminum Company of America
Alcoa, Tenn.

I AM not in favor of having a watertight central stores system. On paper it always has a complete supply of spare parts, but when urgently needed these parts may be on paper only, with lots of excuses forthcoming.

I have found that the most effective system is to have a central store under the direction of the purchasing department with the chief electrician and boiler room foreman having small stores obtained under requisition from the central store. In the case of the former, there are usually so many small and varied parts that he is the only one who knows them. Also, it would be inefficient for him to have to requisition the many small articles needed. He would keep a stock list of his stuff and render it to the proper department for accounting purposes and would anticipate his wants. All foremen in the maintenance department should render weekly reports of their anticipated wants and should be allowed to make a physical check of the supplies and not believe all they see on stock cards. The stock card systems are all right—but many a serious shutdown has been occasioned by incorrect entries on cards.

We have a part of the warehouse fenced off and kept solely for boiler room supplies. It is the duty of the boiler room mechanic, who is responsible to the maintenance foreman, to see that this store is kept up-to-date physically. The stores clerk does the card end of the business. When a boiler is coming off the line and extra equipment is needed he sees that all is ready. He and the stores clerk only have keys to this storeroom. The maintenance department must insure that all the parts for mechanical repairs are in stock. Bearings, thrusts, impellers, glands, bushings, etc., are kept up to the average needed number.

Oils and grease are responsible for sore points over which there is often much argument—especially when it comes to measurement of quantities. It is up to the maintenance department to check with the stores department on all these quantities. Fuel oil should be charged out direct to the power engineer's department, which is responsible for its renewal.

M. C. COCKSHOTT
J. B. Gill Corporation, Long Beach, Calif.

IT would be detrimental to efficient operation of the power department to strictly centralize the material bought for and used only in this department. Certain supplies should be kept in the power house. For example, a couple of rings of packing for a certain pump are needed in a hurry. Long before a requisition could be made out and sent to the storeroom, which may be two blocks away, and the packing brought back, the pump is, or should be, packed and in operation.

But neither am I in favor of strict decentralization of the power department material, for power houses

GEORGE S. BILLMAN

Assistant Chief Engineer, Nicholson File Company, Arcade Works, Anderson, Ind., contributor to the Forum.

nowadays are not built to store such bulky material as fire brick, boiler tubes, etc.; all such material should be kept in the storeroom. At the end of each month the head of the department should give the storekeeper a list of the material he has on hand, and in return he should get a list from the storekeeper of the material in the stores for his department; the two men can then get together and make up the list of supplies that will be needed during the month.

By following the method outlined the stock will always be kept at the proper proportions by making both parties responsible. By charging to a department only the material used by that department, when it is bought, there will never be an oversupply. If the plant is large enough to employ a regular maintenance engineer it will be his duty to look after the stock.

One great disadvantage to both us and the storekeepers is that some managers think that anybody can be a storekeeper. This is a bad mistake; a good storekeeper is worth his wages many times over to any company. Frank is right, "just a kid" won't do.

M. B. KRAMER, *Chief Engineer*
El Paso Milling Company, Ltd.
El Paso, Texas.

STORES has been, in my experience, a question of perpetual and vexatious disappointments. It is a matter of paramount importance to the maintenance man. His success in keeping the plants going at the least possible cost rests with stores to a considerable extent. The most efficient organization in any plant will break down under the load of poor stores. The maintenance crew must have the *right* part *when* needed or costs will mount.

Take, for example, the simple matter of a machine bolt. A maintenance man goes to stores for a ⅜x2½-in. bolt. The clerk looks in the bin and finds none; he "forgot" to order. So the workman, to get the machine going, uses a 3½-in. bolt. The bolt must be cut off so he uses a bolt cutter, hand hack saw, or chisel. If he breaks a saw blade or dulls his chisel, he goes to stores or to the blacksmith. The job costs more from any angle, the machine is down longer, and there is just that much less production.

A small matter, stores argue, Oh, yes. *But* maintenance is made up of a conglomeration of small jobs. Too many times have I heard the answer, "We made a temporary repair. When we get the proper parts we will do the job *over again.*"

It has been my experience that when maintenance stores are segregated from production stores conditions are far better than when both are together.

I do not believe that each unit of the power and maintenance organization should have its own stores but I am convinced by sad experience that maintenance stores should be an independent unit. As maintenance is dependent on proper stores so should the man held responsible for maintenance be responsible for his stores.

With centralized stores the maintenance man's hands are tied; with decentralized control he cannot duck responsibility. If he has a storekeeper that does not do his work, he can get one that will. With centralized stores he gets a laugh and the condemnation of the management because maintenance costs are high and the work not done with dispatch.

With centralized stores the storekeeper is responsible to the man who is not responsible for maintenance and in my humble opinion that is just plain silly.

FREDERICK W. CARTER
In charge of Power and Maintenance
Waterbury Clock Company
Waterbury, Conn.

THE question of centralization or decentralization of stores cannot be solved by any rule of thumb method; it depends upon variable factors inherent in the business. One of the most outstanding of these is the size of the plant. Thus it would be absurd to have a decentralized system in a small plant. On the other hand it is quite conceivable that in a large factory some form of, although not complete, decentralization would be preferable. For instance, if certain departments were especially heavy in repair and maintenance work as compared with others, it might be advisable to give them their own stores.

In the long run the question becomes one of relative cost. By this is meant cost of delays as well as cost incurred in upkeep. It may be difficult to arrive at relative costs of delay but to do so is necessary.

In a majority of instances, whether the plant be comparatively small or very large, it would appear that the centralized store is most economic as well as most efficient. This statement can be true, however, only where the store itself is run on efficient lines. The argument advanced in the discussion that stock was not on hand and that the storekeeper never knew whether an item was in stock or not indicates clearly that the store discussed was operated inefficiently. It is the primary business of those in charge to know whether or not a given item is in stock by means of keeping their files up-to-date. An accurate system of recording is the solution to these troubles and if this is done there will be eliminated the second objection, viz: lack of knowledge of the parts. It is quite obvious today that the use of a little intelligence can overcome, in such instances, the lack of technical knowledge. DERMOT A. DAVIES

Director of Commercial Research
Dominion Rubber Company, Ltd.
Montreal, Canada

IN a small plant greater savings and a closer check on material may be obtained with centralized stores, but in a large plant a centralized store becomes unwieldy.

For instance, boiler house repair parts, if stored in some convenient but otherwise out-of-the-way place in the boiler house, will facilitate the dispatch with which

repairs can be made, and save time in handling of the material. When a proper stores inventory is kept, of the supplies used as well as the supplies on hand, there should be no reason for material shortage.

Take the case of a pulp mill where ground wood pulp is manufactured. The stones used are heavy, and are quite easily broken, and the less they are handled the better. It is therefore customary to unload them from the cars at the ground-wood mill where they are stored adjacent to the point of use, the mill being equipped with crane and hydraulic jack. The saving in labor due to decentralizing this one item alone is well worth considering.

In the matter of electric motor spares and repairs, the heavier items may be handled with greater dispatch if decentralized. Spare armatures can be set in racks where they will not be damaged, as might be the case if placed in a central store. Complete units of coils and insulation for important motors may be stored more conveniently and will receive less handling if decentralized.

For all of the items mentioned, as well as for heavy castings, spare rolls, etc., a systematic check of the inventories by those responsible will do away with any possibility of shortage.

In regard to small items such as shelf hardware, electrical fittings, steam and water supplies, centralized storing is the only way in which a proper inventory can be kept, and since this material is easily handled, it does not require a large stores force.

H. E. STAFFORD
Electrical Engineer, Port Arthur, Ont.

Should Maintenance or Production Department Control Cranes, Elevators, and Trucks?

(Question presented in the April issue)

I BELIEVE the production department can supervise the operation of most types of elevators now in service about as well as any other department. But I would advocate the employment of a better type of operator in place of the average workman, and thereby obviate the present practice of putting a man on as operator, who is believed to be unfit for other duties.

As for trucks, I believe they should be operated by a man from the maintenance department who is mechanically inclined and who knows when the truck isn't functioning as it should. Such a man can often prevent serious breakdowns and delays, by making minor adjustments, or by taking the truck out of service for repairs, whereas the ordinary operator from the production department, who is here today and gone tomorrow, will lack the mechanical ability to interpret signs of impending trouble which means in most cases, that the equipment will be operated until it fails. This method of operation always costs more than if it was attended to before failure. The mechanically inclined operator will not subject the truck to abuse, such as suddenly throwing it into reverse, nor will he put it through stunts that will cause undue strains.

An example comes to mind where a new electric truck was purchased, and an attempt was made to pick the best man in the production department to operate it. One day while stacking materials he allowed the hoisting apron to come down and rest on one of the crates. Doing this stalled the motor which he left connected to the battery. The controller was not turned to the off position. He permitted the motor to remain stalled while he roamed around the plant to notify the electrical department that the truck would not run. During this time the motor was practically ruined. Most any operator, with electrical or mechanical training, would have returned the controller to the off position, and in most cases, would have tried reversing the apron to see if it would run in the other direction.

As for cranes, there should be no question of the wisdom of having the maintenance department operate them. They are intricate pieces of machinery, with gearing, brakes, ropes, and complicated control equipment, operating under conditions of hard service, and easily strained and damaged through improper operation.

Most of the difficulties arising from the production department's operation of cranes is due to labor turnover, making it impossible to keep trained operators on them. About the time one feels that he has trained operators on the job, a new man from the production department comes in on the midnight shift, and next morning there is a crane to repair and no one knows how it happened.

Cranes are vital links in the chain of production that causes a tie-up, or loss in production, when out of order. Outside of this, they are a hazard to personal safety when improperly handled.

It is my opinion that worthwhile savings are being overlooked in a great many cases today through the improper operation of equipment. Extreme care is being taken to provide proper equipment, and proper repairs, and then its operation is intrusted to unqualified operators. A 45-cent-an-hour operator, not fitted to the post, will keep expensive mechanics busy making frequent repairs, and creating, at the same time, production delays.

A skip hoist used for supplying coal to a boiler house and also handling the removal of ashes, was operated by any one in the vicinity. It was broken down continually or something was wrong with it, but no one ever knew how it happened. This method of operation, outside of causing expensive repairs, often meant the employment of a gang of workmen with shovels and wheel barrows to furnish coal to keep the boilers on the line. Finally, a fair mechanic was delegated to operate the hoist, and who was capable of making minor adjustments and the reporting of trouble beyond his control. This practice completely eliminated delays as well as expensive repairs. When not needed on the hoist, he was available for other repair work about the boiler house.

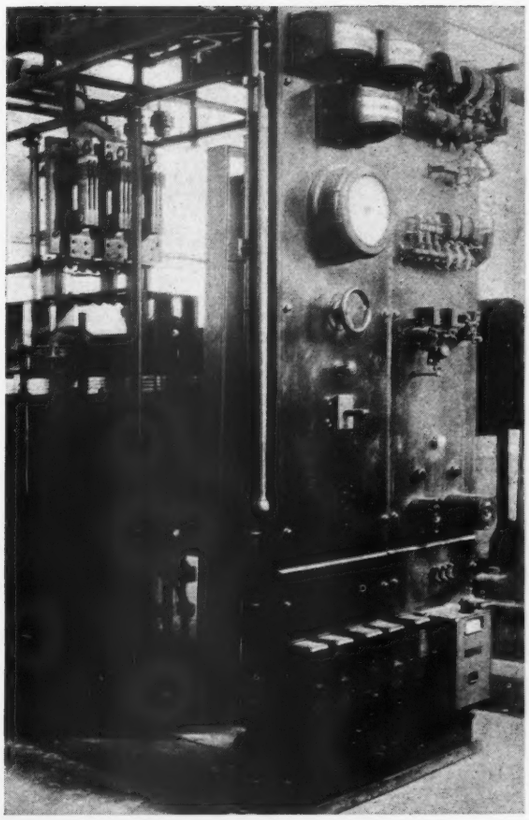
For the operation of these elevators, trucks, and cranes, provide sufficient incentive for the better-than-average operator to keep them on the job and watch the delays and expensive repairs drop. The maintenance department is the place to get these operators. After a short apprenticeship of mechanical duties they can become operators. The best mechanics obtainable are none too good for crane repairmen.

MARIN PHILLIPS, *Electrical Superintendent*
International Paper Company
Niagara Falls, N. Y.

Modernization Begins in the Substation

By H. E. STAFFORD

Electrical Engineer
Provincial Mills, Limited
Port Arthur, Ont., Can.



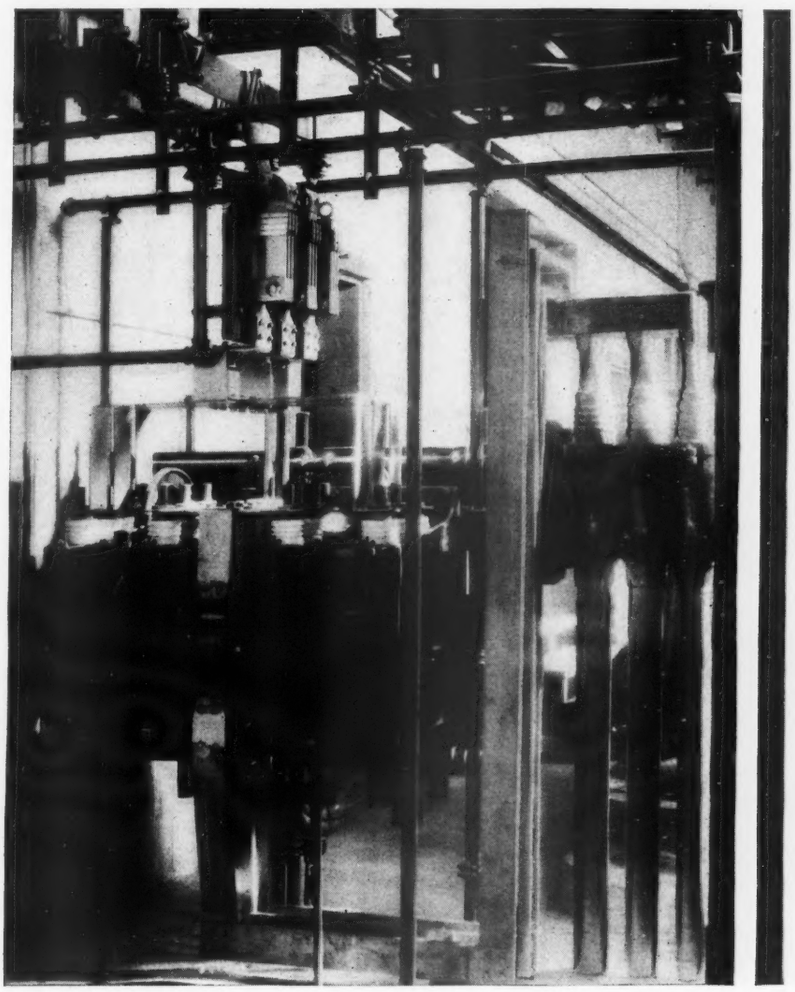
Across-the-line starting has been adopted as standard. A typical control panel is shown here.

TO increase the output of a ground wood or mechanical pulp mill from 30 to 80 tons per 24 hours, an increase in connected load of from 2,765 to 7,282 hp. was necessary. Thus it follows that before the plant could be expected to increase its output approximately 163 per cent, the substation would first have to be modernized to handle a corresponding increase in load.

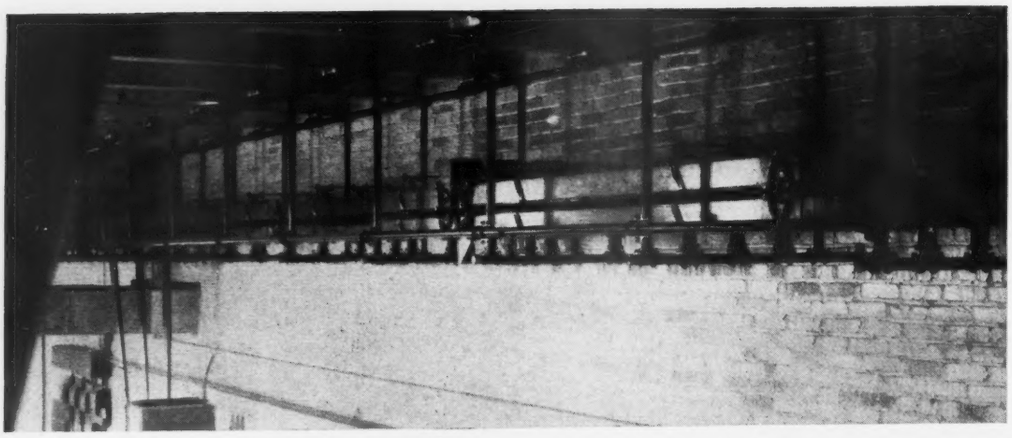
The original load power was supplied at 550 volts from a substation through two feeder panels and two overhead lines. One line consisted of two parallel circuits of 500,000-circ. mil W. P. cable, whereas the other consisted of two parallel lines of 750,000-circ. mil W. P. cable. The distance between the two buildings in a straight line is approximately 375 feet.

As the cost of copper to supply the extra load, together with the necessary steel supporting brackets, was considerable, and since the transformers then in use were inadequate for the load, it was decided to install the required transformers in the addition to the mill and to run one primary line from the main substation to the new substation.

With a primary voltage of 22,000 volts there were only two alternatives in connecting the two stations. That of using steel towers and an overhead

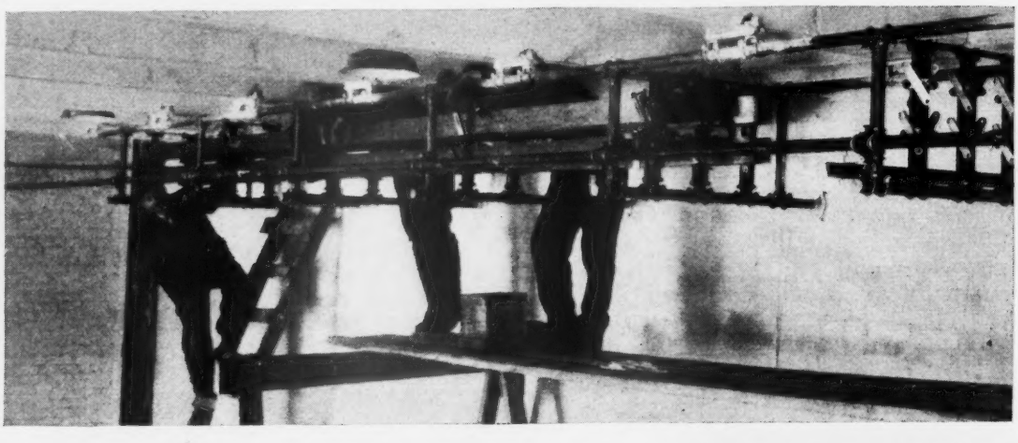


Rear of motor control panels showing the compactness of the bus feeders and other equipment.

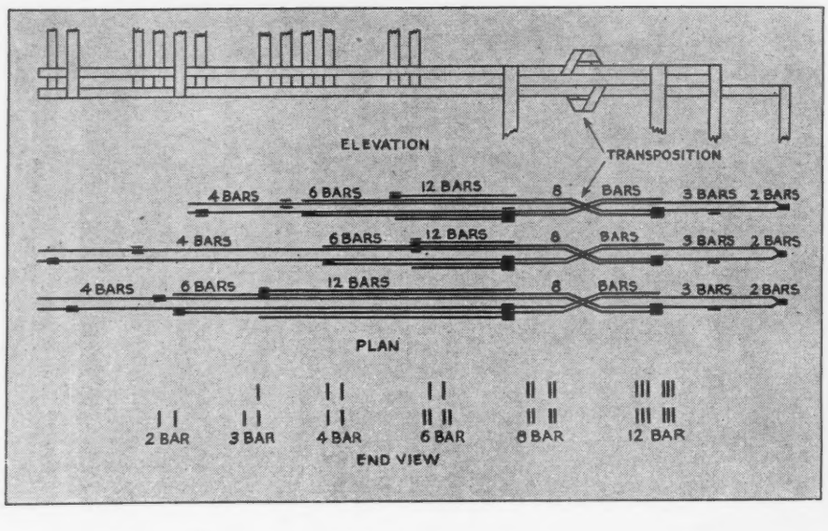


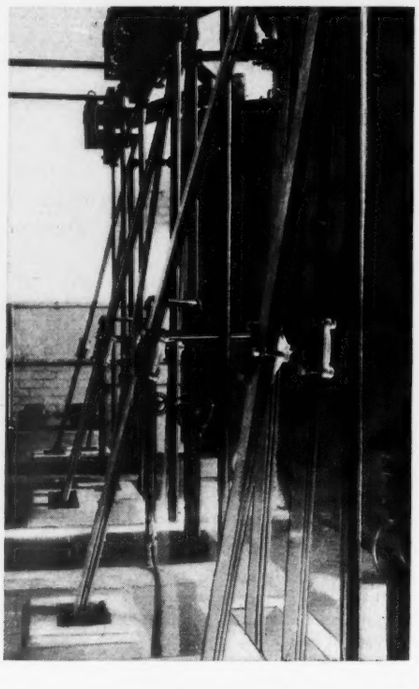
As the bus and its supporting structure appear in the completed state.

A section of the secondary bus feeder under construction.



Elevation, plan and end view details of the hollow bus formation.



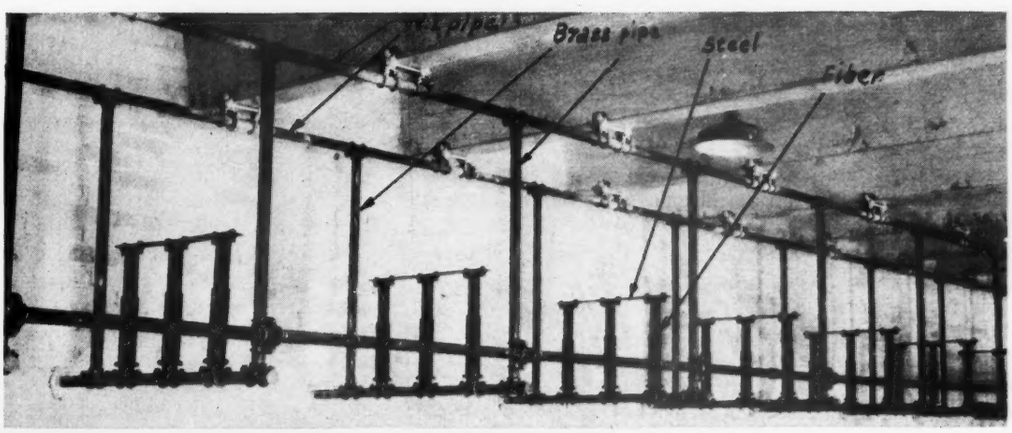


Type of construction employed in passing the circuit through the floor. In the background is the small m.g. set for charging the control storage battery.

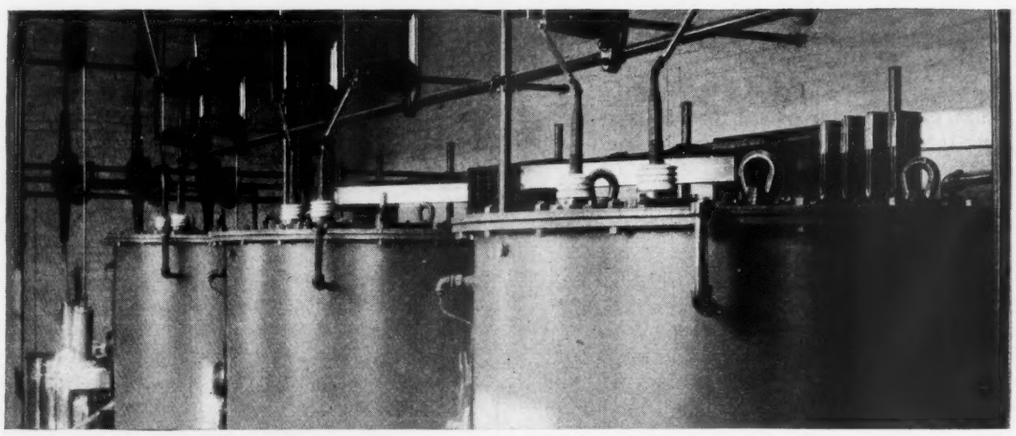
line was discarded in favor of running underground, since by this method auxiliary apparatus such as lightning arresters, etc., would be eliminated, as would the danger of the high-voltage lines crossing over buildings and through a yard where a locomotive crane is in constant use. In addition, the estimated cost of the underground method was one-half that of the overhead method.

From pothead to pothead the underground distance was 440 ft. Several difficulties were presented in making the underground passage, chief of which were the necessity of running underneath buildings, crossing water and stock mains, and passing through a yard where it was necessary to excavate at various times in order to repair pipe lines, etc. To overcome the various difficulties the cable was laid in a wooden trough from two to four feet underground, the top of which was covered with four inches of concrete.

As shown in accompanying illustrations, the trough was laid with the top open, the top being placed after

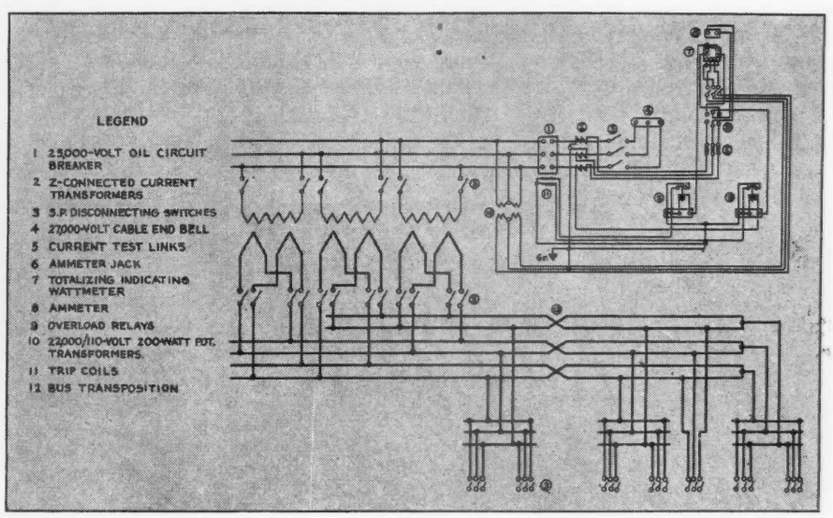


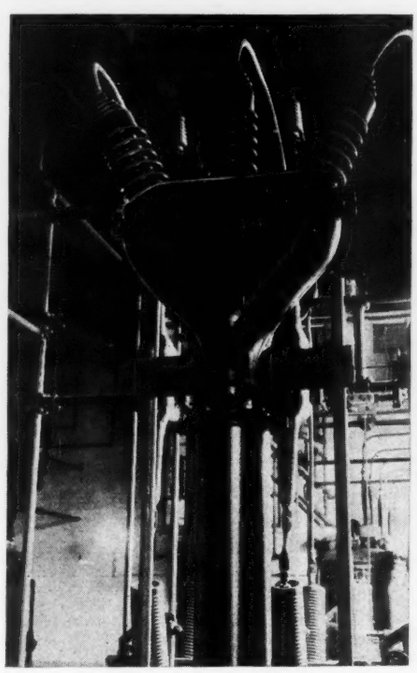
Type of support used for the secondary bus.



Showing method of connecting the transformers to the disconnecting switches.

Schematic wiring diagram of the transformer station showing transposition of secondary bus and taps to branch feeders.





Substation end of the underground cable with its pothead and other accessories.

the cable was laid. One view shows a section of the trough, another a section after the cable was laid, and still another, a section after the cover was placed and waterproofed with tar paper and concrete forms in place.

After taking the foregoing precautions the whole duct was covered with concrete which formed an arch over the top and sides so that when the form lumber decays the cable is protected from injury, for example, from a workman's pick. Targets were placed in every direction taken by the cable so that a permanent record of its location is available.

In the substation, the cable terminates in a cable end bell or pothead mounted on an 8-in. conduit through which the cable passes on its way to the manufacturing buildings. This three-conductor, 27,000-volt cable is paper-insulated, lead-covered and steel-armored in one continuous length and at each end a 25,000-volt oil circuit breaker and a set of disconnecting switches are provided.

In addition to the 25,000-volt oil circuit breaker previously mentioned

the station equipment consists of three single-phase, oil-insulated, water-cooled 2,150-kva., 22,000/575-volt transformers connected delta-delta, and one control panel and the necessary potential and current transformers for control and metering. The transformer station measures 39 x 17 ft. which is conservative of space for a 6,450-kva. station.

Several departures in station design may be noted in this installation. The high-tension connections are all at the front, whereas the low-tension connections are against the wall on both the power and instrument potential transformers. Another feature is the absence of the secondary bus structure in the station. The secondary bus is run on the ceiling of the motor and control room below the station, and the low-tension delta is formed at this point. Four leads are brought out from each transformer and taken direct to the bus below.

One view shows the connections from the transformers to the disconnecting switches, another shows the type of construction employed in carrying the circuits through the floor. Each primary bus lead consists of three 4 x ¼-in. hard-drawn copper bars. The secondary bus is probably the largest of its type ever designed. It is 137 ft. long, has a capacity of 12,000 amp. maximum, 9,000 amp. continuous duty, is of hollow formation and required 6 tons of copper in its construction. Details of the hollow bus formation are shown on page 578. Another view illustrates the type of support used, which consists of fiber tubes mounted on 1¼-in. pipe fastened to the supporting framework with alloy clamps. A steel bar is connected across the tops of the three supports as shown. The supporting framework is of 1¼-in. pipe fastened to the I-beams with suitable clamps. The connections between the top and bottom supports is made up of 1¼-in. extra heavy brass pipe which breaks the magnetic ring.

From the views which show a section of the bus under construction and a section of the completed bus it will be seen how the bus was built up in a hollow formation, the number of bars required depending on the load at that point. The two legs of each bus and phase are transposed as near the center of the load as possible.

Taps are taken from the bus direct to the various control panels, as shown in the photograph and on the wiring diagram of the station. The control panels are placed in pairs so that one tap from the bus serves both. These taps consist of four parallel bars of 5 x ¼-in. copper.

At present there are four 1,400-hp. and one 1,000-hp., 550-volt synchronous motors and an induction motor load of 682.5 hp. fed from the bus, with provisions for one additional 1,400-hp. synchronous motor and 300 hp. in induction motor load.

Modernization was carried beyond the substation and into the plant, where the original synchronous motors had been equipped to be manually operated with reduced voltage at starting. Three 1,400-hp. units just installed are arranged for full-automatic, across-the-line starting. The automatic panels for two of these motors; two for each motor, are shown in an accompanying illustration. Another view shows the apparatus at the rear of one of these panels. In this illustration, the two solenoid-operated oil circuit breakers connected in parallel, together with field rheostat and field discharge resistance, current transformers and bus structure, are shown. The bus terminates at three potheads where a junction is made to three parallel runs of three-conductor, 750,000-circ. mil, 600-volt, paper-insulated, lead-covered cable extending in 4-in. conduit to the motor terminals.

Excitation for these three synchronous motors is supplied from a 100-kw., 250-volt, m. g. set. This set, as well as the balance of the induction motor load, is fed from the main bus through a 1,000-amp. oil circuit breaker to a gutter box equipped with individual service switches.

In connection with the automatic control of the synchronous motors, a 125-volt, 60-amp. storage battery is required, which is being charged from a small motor-generator set that floats across the battery and the line.

The actual operation of the equipment added at this time brought this phase of the plant modernization to a successful conclusion.

(Left) Cable trough installed between the two substations. It was laid with the top open. (Center) A section of the trough with the underground cable in place before the top was put on. (Right) After the cover was placed and waterproofed with tar paper, concrete forms were used for the protecting cover.

Insulating Materials Used in Winding and Banding Rotors

Life of rewind jobs is largely dependent on the insulation used—Here are details that will help the repair shop to approach factory standards

By A. C. ROE

Renewal Parts Engineering Department Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

USEFUL life that can be obtained from any rewound armature depends considerably upon the proper selection and application of insulating materials during the winding and bending processes. These materials vary in grade, types, and shape, and the correct shape is just as important as the proper grade.

Insulating materials used in banding rotors can be be divided into groups, such as tapes, twines, sheet materials, molded materials, etc. The term "cut insulation" is used to distinguish those items of sheet material that are cut to a definite size, and are destroyed when removing the old armature winding.

The division of insulating materials into groups also permits the manufacturers of electrical equipment to supply the material for any piece of apparatus and to suit any condition, as will be explained later.

TWINE is used to tie the various items of cut material, in place temporarily; a good, tough twine, approximately 1/32 in. in diameter can be used for most applications.

TAPES—Under this heading there are treated and untreated tape, asbestos tape, and friction tape. These vary in width and thickness, according to the application, as described below.

Cotton tape, untreated, 0.007 in. and 0.011 in. thick, and 1 in. wide is the most commonly used.

Surgical tape, 0.023 in. thick and in widths varying from 1 in. to 2½ in. in ½-in. steps.

Treated tape, tan, bias-cut, seamless, tacky finish, will meet all requirements. The bias material can be applied smoothly and tightly to regular- or irregular-shaped objects, and if it is desired to have the tape slide during application, the surface being taped can be brushed with a clear (amber) varnish or shellac.

Friction tape 1 in. wide, gray, bias-cut, tacky, will be found suitable for all applications. The bias cut permits tight application to all types of surfaces. The gray bias tape is superior to the straight-cut, sticky, black tape, for coil support insulation, filling in, and so on.

Asbestos tape in ¾-in., 1-in. and 1¼-in. widths will cover the range. This tape is used under core bands and to divide bands into sections, as will be shown later.

Tape, twine, banding wire, solder, varnish, soldering flux, cements, shellacs, etc., are classified as bulk materials, can be purchased in any quantity, and in the majority of cases can be carried into storeroom stocks.

There are numerous grades and makes of the various items of bulk material, which makes selection difficult unless a winding material drawing that lists all the necessary items for any particular armature is available. The winding material drawing furnished by the manufacturer of the apparatus lists the width, thickness, grade, etc., of each item of bulk material that has been proven satisfactory by test and experience for the application indicated on the drawing.

SHEET MATERIALS—Under this heading are the most important insulating materials; the importance applies not only to the grade, type, and thickness of material, but to the shape and proper application. All items fabricated from sheet material are classified as cut insulation, as all sheet material must be cut to definite shapes or sizes before it can be applied.

Fishpaper, gray, untreated, in rolls and sheets, has a wide range of uses. When the cut pieces have to be bent, the grain of the paper must run parallel to the bend.

Fishpaper, paraffined, can be obtained with one or both sides coated with paraffin. This material is used mostly as winding cells in open-slot machines, and eliminates the necessity of paraffining the slot sections of the coils while winding the rotor.

Fishpaper, white, is a high-grade paper used as backing for a thin, high-dielectric test, mica-and-fishpaper sheet material.

Treated rope cement paper is used extensively for coil support and band insulation. This material has a higher dielectric value and better moisture-resisting properties than fishpaper, but will tear easily and must be applied to straight or flat surfaces.

Treated Fuller board is a dense, tough material; the treatment gener-

ally consists of applying a clear or amber baking varnish to each surface. This material is used for washers or odd shapes that are punched or sawed out.

Treated duck, sometimes called "oiled duck." Untreated duck is a strong, tough material highly resistant to tearing and abrasion. Treated duck is used between layers of coil ends, at diamond points, between leads, and in places where protection against abrasion is required.

Treated asbestos cloth. This material closely resembles treated duck, and it has the same features, with the additional quality of being able to withstand higher temperatures.

Treated cloth, straight-cut, tan, or black, has a high dielectric value. It can be applied to regular or irregular surfaces and is used extensively for secondary winding cells, and coil support insulation.

Friction cloth is similar to friction tape, except that the base cloth is thicker and the average width used is 6 in. It is used as a pad under the top layers of coil leads, and to hold in place, or together, other items of cut insulation.

Drilling is an untreated cloth used to cover irregular parts of coil supports, or, in conjunction with cotton tape, to cover odd shapes, where varnish can be applied and where a tough, flexible, easily-shaped material is required.

Hard wood, generally maple, is used for cleats, cross-connection supports, etc., and is treated in paraffin or varnish when used for bracing windings.

Fiber is used principally for wedges to retain windings in the slots. The thickness varies and the wedges, ⅛ in. thick or more, are machined to fit the wedge grooves in the slots.

Micarta is used in sheets and tubes. The sheet material is used as slot fillers for windings operating at high temperatures.

Molded Micarta is employed for irregular shapes, used in quantity, that would be expensive to machine.

Banding clips, used to hold banding wires together, are cut from tinned sheet steel; steel is selected because of its high resistance and strength. The high resistance tends to reduce eddy currents.

Banding wire is, in the majority of applications, a high-grade, tinned, steel wire. Bronze wire is used in a few cases.

Combination slot insulation is composed of an untreated-fishpaper base, with treated cloth cemented on. It is used principally as slot cells and separators in partially-closed-slot motors. The grain of the fishpaper should run parallel to all bends made in the cell, and the fishpaper put next to the iron in the slots. The fishpaper provides mechanical strength, and the treated cloth increases the dielectric strength.

Mica and fishpaper is a combination of thin fishpaper, two or three layers of mica splittings, and Jap paper. It is used where a flexible, strong material is necessary that will maintain a high dielectric strength when subjected to high operating temperatures.

The materials listed above, although few in number, have been selected and found satisfactory for a wide range of application, after a series of tests. These tests included life under various conditions, ease of application, resistance to injury, and high-voltage, breakdown tests.

For the convenience of those who desire to rewind their motors and use materials and methods closely paralleling those employed for the original factory windings, it is evident that a

WINDING MATERIAL CLASSIFICATION FOR RAILWAY, POWER, AND INDUSTRIAL A. C. AND D. C. MOTORS

Class 3 ← Complete Winding Material plus Mechanical Details and Molded Mica Parts → 3

Class 2 ← Complete Winding Material → 2

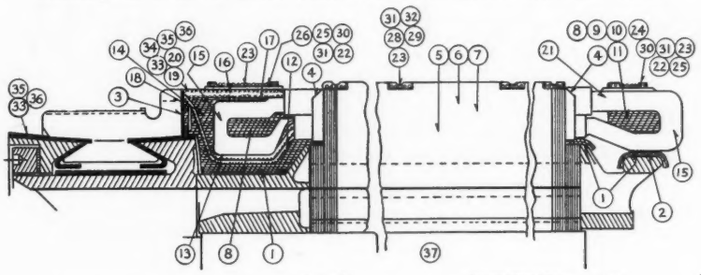
Class 1 ← Cut Winding Insulation → 1

Sub Classifications	Material Included	Material Included	Material Included
A Cut Core Insulation	All Cut Insulating Material used to prepare the ends of core for winding, such as, treated cloth caps, coil support, molded paper rings, fiber rings, canvas caps.	Cut Winding Insulation Class I; plus all bulk materials such as, tapes, twines, varnishes, solder, soldering flux and banding wire.	Complete Winding Material plus all necessary cleats, bolts, tie rings, formed copper connectors, brace or support arms.
B Slot and End Insulation	All Cut Insulating Material used when winding, such as, cells, fillers, wedges, spacing blocks, wood bracing blocks, tie blocks, micarta, tubes, etc.		
Connecting Material for A. C. Stators or Rotors	All Cut Insulating Material used when connecting, such as, cable for leads, and for star or parallel rings and jumpers; figure 8 or sleeve connectors; wood wedge blocks for soldering, canvas caps, etc.	*NOTE:* *This material is placed in a separate class since it is generally more satisfactory to purchase it in bulk.* *Bulk material is not supplied under Class 1.*	Temperature indicating coil wiring details. Wood forming blocks for closing the open end of shove-through type coils.
C —OR—			
Cross Connecting Material for D. C. Armatures	All Cut Insulating Material used for cross connections, such as, cable, wood supporting or spacing blocks, micarta tubes, mica washers, etc., necessary to install the cross connections.		
D Cut Banding Material	All Cut Insulating Material necessary to install the bands and segmental bands with keys and wedges, wood wedge blocks for soldering riser neck commutators and tin clips.		All Molded Mica rings and parts.

All the items originally used to install the winding at the factory.

Cut Insulating Material means any item that is cut to a definite size or shape, "does not include bulk material."

Winding Material For 514 A-(New Type) 514 AT-514 PR Traction Motor



ITEM	DESCRIPTION AND MATERIAL	STYLE	MATERIAL NO.	REQ.	APPLICATION
* 1	72 Yd. of .010x1-in. Treated Cloth Tape	1219		1	Front and Rear Coil Supports.
* 2	Insulating Channel		456512	1	Rear Coil Support.
* 3	Fuller Board Washer		540898	1	Back of Commutator.
4	Fish Paper U-Piece		367024	54	Ends of Slot.
5	Fish Paper Winding Cell		509863	27	Bottom.
6	Fish Paper Winding Cell		499702	27	Top.
7	Fuller Board Separator		510105	27	Between Coils in Slot.
8	Treated Duck Strip		510026	2	Between Front and Rear End Wdgs.
9	Treated Duck Strip		508413	2	Between Rear End Wdgs.
10	Treated Duck Strip		510027	2	Between Rear End Wdgs.
11	Treated Duck Strip		510029	2	Between Rear End Wdgs.
12	Treated Duck Piece		510024	27	Between Layers of Bottom Leads.
13	Treated Duck Piece		510039	27	Between Coil and Bottom Leads.
14	Treated Duck Piece		520790	27	Between Point of Diamond and Leads.
15	Treated Duck Piece		510025	54	Between Coil Ends.
16	Treated Duck Strip		508417	1	Between Coil and Top Leads.
17	Fish Paper Piece		499703	1	Under Top Leads.
*18	1½ Yd. 0.023x2-in. Treated Surgical Tape	1237		1	Through Bottom Leads.
*19	1½ Yd. of 0.023x2¼-in. Treated Surgical Tape	1237		1	Through Top Leads.
*20	½ lb. Rolls of 1-in. Bias Friction Tape	1821		2	Around Top Leads.
21	Fuller Board Piece		565368	27	Between Coils at Rear End.
*22	6 Yd. 0.010x1-in. Treated Cloth Tape	1219		1	Level Under Bands.
*23	200 Yd. of Machine Thread.	1828		1	Assist in Banding.
24	Fish Paper and Mica Strip.		508425	2	Rear End Coil Band.
*25	Asbestos Tape. Spec. *240010	1598		1	Under Coil Bands.
26	Fish Paper and Mica Strip.		508426	2	Front End Coil Band.
28	Tinned Steel Strips		510084	8	Under Core Bands.
29	Tinned Clips		303468	32	Core Bands.
30	Tinned Clips		303490	16	End Bands.
*31	5½ lb. 0.064-in. Banding Wire	1474		1	Bands.
*32	¾ lb. of Ribbon Solder	35		1	Bands.
*33	35 Yd. of Twine	2973		1	Com. V-Ring Top Lead Back of Com. Neck.
*34	1 lb. of Cement	677		1	Back of Com. Neck.
*35	⅛ Pt. of Shellac	1104		1	Back of Com. Neck and V-Ring.
*36	⅛ Pt. of Shellac	1103		1	Back of Com. Neck and V-Ring.
*37	1½ Qt. of Varnish	2227		1	Finish.

		STYLE NO.	ITEMS
(A)	Cut Core Insulation	441786	2-3
(B)	Slot and End Insulation	441787	4 to 17-21
(C)	Connecting Material		
(D)	Cut Banding Material	441788	24-26-28 to 30
(1)	Cut Winding Insualtion	441789	2 to 17-21-24-26-28 to 30
(2)	Complete Winding Material		All Items.

*These items are not included in style numbered sets, but should be purchased in bulk.

rewind problem can be divided into three groupings of winding material, and the material so arranged as to make it practicable for anyone to order just the material needed.

The first group is termed "Cut Winding Insulation" and includes only those items of sheet material that are cut to a predetermined size, and are absolutely essential in rewinding an armature.

The first grouping can be further divided into four sub-classifications, such as, *A*, cut core insulation, *B*, slot and end insulation, *C*, connecting or cross-connection material, and, *D*, cut banding material, as shown in the table. Thus it is possible to order under Class 1, the necessary cut material for the whole or any part of an armature or stator.

The second grouping is termed "Complete Winding Material" as it includes all Class 1 or "Cut Winding Insulation," plus the necessary bulk material such as tapes, twines, varnish, banding wire, etc., to wind the armature.

Thus Classes 1 and 2 separate the common materials that are carried in the storerooms of the average winding department, from the special-shaped, cut material.

The third grouping, Class 3 in the table, is termed "Complete Winding Material plus Mechanical Details and Molded Mica Parts." It includes every item required to install and finish the winding.

The three main and four sub-classifications in the table form the base from which winding material drawings are made up, as the items can be tabulated in sequence of application, and grouped by item number into the proper classifications.

The illustration on this page shows a typical example of a winding material drawing, indicating all items required to wind an armature. The bulk material, items 1, 18, 19, 20, 22, 25, 31 to 37, are detailed to the exact amount required. The width, thickness, and material numbers are given.

The winding material drawing is also a guide to indicate where each piece should be applied. Likewise, after each item on the drawing a brief note indicates its application.

These winding material drawings are as important a part of the rewinding data as is the coil pitch and lead connecting information, and can be used to compute the cost of the material for winding any armature.

The economies obtained by the manufacturer in keeping the different kinds, shapes, and sizes of materials to a minimum, and of identifying each cut piece by a style number, are also available to the owners of a large number of different motors, as a study of the various winding material drawings will show that one or more items or cut materials are used on a number of other armatures; thus these items can be stocked.

Banding clips are a good example of how a few sizes will cover a large variety of armatures; it is possible to select three of four clips of different lengths and widths, and band all types of armatures with them.

A careful study of the methods of storing and cutting materials used for winding and banding various types of armatures in any plant will indicate that standardized cut pieces and bulk material will result in a saving of time, space, and materials. The reduction in cost and improvement in the work will justify the effort and time expended in the study of materials and methods of applying them during the winding and banding of rotors.

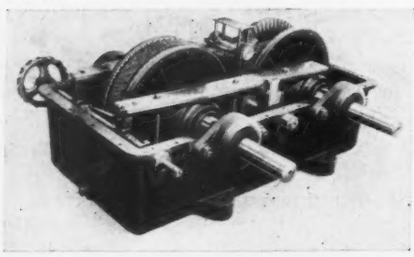
EQUIPMENT NEWS

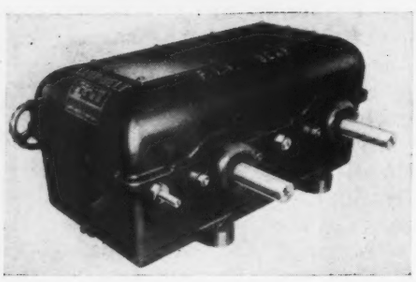
Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these devices, which are designed to improve plant operation or reduce operating and maintenance costs.

Link-Belt "P.I.V." Transmission

AN all-metal, variable-speed transmission has been announced by the Link-Belt Company, Philadelphia, Pa. It is called the P.I.V. gear, the initials standing for "Positive, Infinitely Variable," and indicating the characteristics of the transmission.

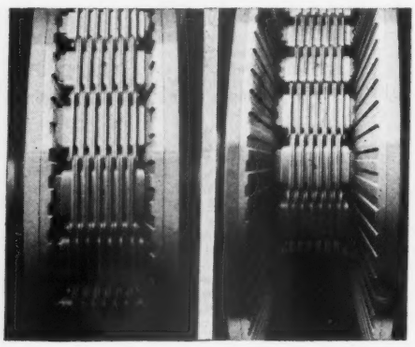
This speed-change unit consists of two pairs of wheels of the opposed conical-disk type, between which a steel chain transmits power. The effective diameters of each pair of wheels can be altered under load to change the speed ratio, without steps and without dependence upon friction. On changing speed, the self-pitching chain rises in one set of wheels and descends in the other, so that while the input shaft connected to a motor or other source of power turns at constant speed, the output shaft is brought to the desired revolutions per minute.





According to the announcement, the original feature of the P.I.V. gear is its use of a positive chain drive to transmit the power. Radial teeth are cut in the conical faces of the driving disks, and the self-adjustable teeth projecting beyond the sides of the chain are arranged positively to engage the radial teeth of the disks.

The chain is made up of a series of steel leaves or links with joints consisting of hardened-steel pins turning



in segmental bushings. There are no teeth on the inner surface of this chain. Instead, what may be called teeth are made up of packs of hardened-steel laminations or slats which extend through slots in the links at right angles to them, projecting about ⅛ in. at each side of the chain. The individual containers which hold the packs of slats are secured in the openings of the links, and within each such container the slats are free to slide from side to side with relation to each other and adjust themselves to engagement with the radial teeth of the disks. The angle of the slat ends, 30 deg., is the same as that of the conical faces of the wheels.

Although of uniform depth, the teeth of the disks widen from the center outward. They are staggered on each pair of wheels so that the slats move back and forth to mesh correctly as the chain comes into contact with the wheels.

All elements of the unit are built into and protected by an oil-tight housing, and are automatically splash lubricated. The movement of the pairs of wheels is controlled by a pair of pivoted levers operated through a hand control shaft with right and left-hand screw motion.

This P.I.V. gear is available in five sizes, from 1 to 10 hp. in capacity, providing speed-change ratios up to a maximum of six to one.

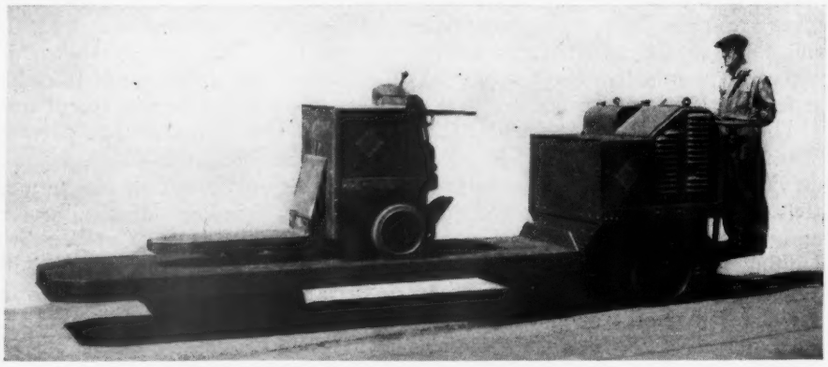
Elwell-Parker Lift Trucks

TWO sizes have been added to the line of electric lift trucks made by the Elwell-Parker Electric Company, Cleveland, Ohio. The big truck pictured has a rated capacity of 10 tons. The lift platform measures 40 x 144 in. and stands 18 in. from the floor. The smaller truck, developed to handle hand-lift truck skids, has a capacity of 1¾ tons. Platform dimensions are 18 x 41 in. with a 7-in. clearance.

Loads on these machines are carried by the front axle. On the larger machine, all four front wheels steer concentrically with drivers on the other axle. The inside wheels turn approximately 33 deg. while the outside pair of wheels turn at a 29-deg. angle. Front wheels on the smaller machines are steered simultaneously with the drivers.

For safety, controls on both trucks are immediately in front of the operator while the two pedals upon which he stands are fitted with special, deep rubber pads for comfort.

The larger truck is fitted with a gas-electric power unit which furnishes current for both the elevating and traveling motors. Batteries may be used in the space occupied by this unit.



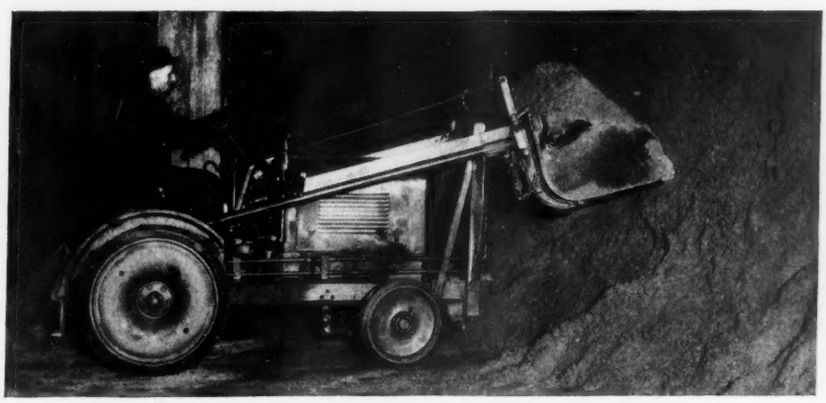
Clark "Clarktor" Shovel

A POWER scoop, known as the "Clarktor" shovel, designed to handle any loose, fluid material such as sand, gravel, bulk cement, clay, etc., has been announced by the Clark Tructractor Company, Battle Creek, Michigan.

Standard buckets hold 9 cu. ft. or 1,500 lb., although larger capacity buckets are furnished when the material to be handled is lighter than sand. Improved hydraulic cylinders enable drivers to pick up and hold the load at any desired point.

Two models of different heights are available; one having an under-bucket clearance, with bucket in dumped position, of 3 ft. 9 in., the other of 6 ft. 5 inches.

A Tructractor chassis is used including standard truck transmission, multiple disk clutch and Clark truck axle. Equipment includes starter, generator, battery, head and tail lights.



Lewis-Shepard Standard and Special Floor Trucks

ANNOUNCEMENT has been made by Lewis-Shepard Company, Boston, Mass., of the completion of its line of standard and special floor trucks.

This line of floor trucks has been designed to meet specific problems. Arc-welding has been used in construction wherever practical. Handling problems that cannot be solved by the installation of the Jacklift and Skid-platform system have been aided considerably by adopting one or more of the designs of floor trucks, it is stated.

National Carbon Adds "Gredag" Lubricants

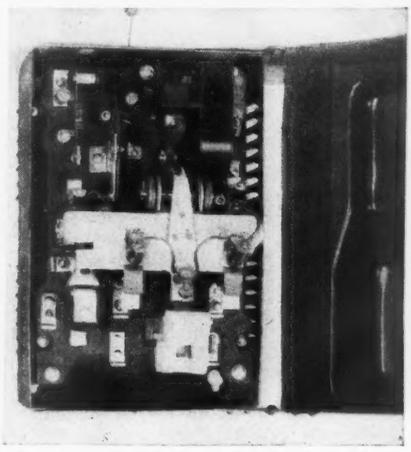
BEGINNING November, 1930, the entire line of "Gredag" lubricants manufactured by the Acheson Graphite Corporation, a unit of the Union Carbide and Carbon Corporation, will be distributed and sold by the Carbon Sales Division of National Carbon Company, Inc., Cleveland, Ohio.

Westinghouse Timestarters

A COMPLETE line of remote-controlled magnetic starters, designated Class 8512, for constant, and adjustable-speed, 230-volt d.c. motors in sizes up to 10 hp., has been announced by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. They provide three points of time-limit acceleration, permitting safe starting of the motor under full or partial load.

Class 8512-A, for constant-speed motors does not provide overload protection or dynamic braking. Class 8512-B, for constant-speed motors provides thermal-relay, overload protection but not dynamic braking. Class 8512-C, for constant-speed motors provides overload protection and dynamic braking. Class 8512-F, for adjustable-speed motors provides overload protection, dynamic braking, and full-field starting.

The complete line is of standardized construction. Different combinations are made possible by the addition of certain parts to a standard chassis. The standard chassis consists essentially of a three-point accelerating contactor mechanically connected to an escapement mechanism. These are mounted as a unit on a molded insulating base. Bobbin-type resistors mounted on the rear of this unit provide the necessary resistance between points of acceleration. The chassis is inclosed in a ventilated, sheet-steel cabinet and is removed by loosening three screws.

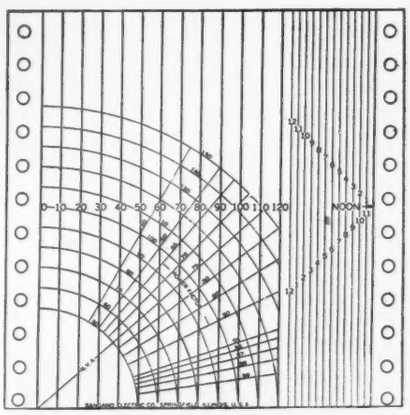


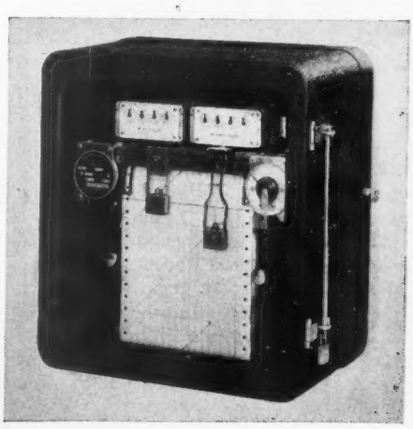
Either low-voltage protection or low-voltage release may be obtained depending on the type of master switch used.

Timestarters can be operated by all types of master switches such as push-buttons, shipper-rod master switches, float switches, pressure switches, and so on.

Sangamo Type S Kva-Demand Meter

TYPE S kva-demand meter is the latest unit to be added to the line of the Sangamo Electric Company, Springfield, Ill. This meter is an auxiliary device controlled by two watthour meters, measuring the energy and reactive component, to give, on a single chart, the following information relative to the load: kva. demand; kw. demand; maximum kw. demand; power factor at time of demand; reactive-component demand, and the time the demand occurred; the energy component in the kilowatt hours, and the reactive component in the kilovolt-ampere-hours.





The measurement is so made as to define the kva. demand as the vector

sum of the voltamperes in the individual phases, and, therefore, agrees with the generally accepted definition of power factor and kva. in polyphase circuits. The power triangle, corresponding to any given interval, is drawn on a strip chart.

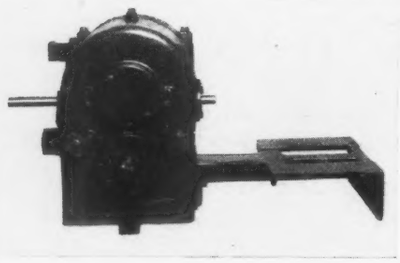
Units can be built for either 50- or 60-cycle operation, and, as it is generally used with meters employing instrument transformers, the motors are regularly built for 115-volt operation.

All motors are of the self-starting, shaded-pole type. Ball bearings, with adequate oiling space, are provided in both upper and lower bearings. The latter is also equipped with a spring support, thus providing easy adjustment. The synchronous speed of the timing motor is 1,200 r.p.m. for 60 cycles, and 1,000 r.p.m. for 50 cycles.

Gears and Forgings Two-Speed Gear Unit

A TWO-SPEED gear unit of the fully inclosed, dust-proof, split-housing type, has been announced by Gears and Forgings, Inc., Cleveland, Ohio.

Speeds are controlled from the out-

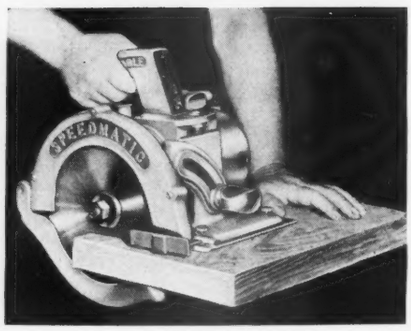


side of the unit by the conventional ball and socket shift lever which operates a double-jaw, heat-treated, alloy steel clutch. This clutch is of the ten-jaw type, facilitating engagement at any speed or load.

All gears and forgings are of forged nickel steel, heat-treated, ground, and hardened. The worm gear is of S.A.E. 65 bronze. Principal bearings are of the anti-friction type. Arrangement of gears maintains the oil level below the input and output shaft, thus eliminating oil leakage.

Porter-Cable-Hutchinson Type K-9 Speedmatic Saw

A HAND saw, known as the Type K-9 Speedmatic, has been placed on the market by the Porter-Cable-Hutchinson Corporation, Syracuse, New York. A 1¼-hp. motor drives the 9-in. saw blade at a free speed of 5,000 r.p.m. and at approximately 4,000 r.p.m. under the average cutting load. This model



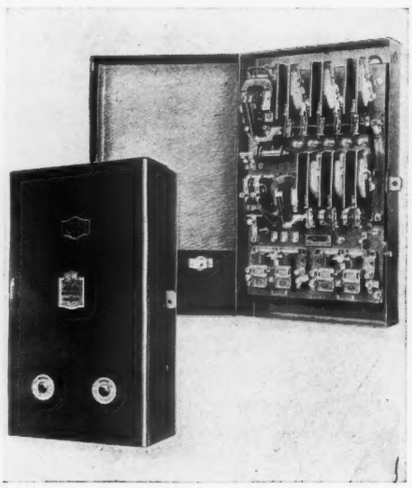
will cut a maximum depth of 3⅛ in.

Both depth and angle adjustments are made by means of a thumb-screw. The motor is cooled by a turbine fan which draws the air in through the commutator and expels it through the saw housing and a special opening to blow the dust away from the cutting line. Four S.K.F. ball bearings are used. Accessories include rip guide, combination wrench and screw driver, 15 ft. No. 14 rubber cord, switch in handle and a combination blade and carrying case.

Cutler-Hammer Automatic Controller

CUTLER-HAMMER, Inc., 150 12th St., Milwaukee, Wis., announces the development of an automatic controller for two-speed, consequent-pole type (reconnected) squirrel-cage motors. This controller, known as Bulletin 9739, functions to start the motor and to change its speed by reconnecting the motor windings. It provides thermal overload protection at both motor speeds, and low voltage protection. A separate pushbutton master switch with "stop," "low," and "high" buttons provides three-wire remote control.

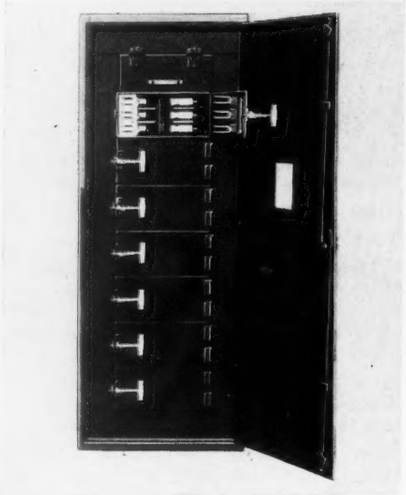
These controllers can be furnished for constant-horsepower, constant-torque or variable-torque motors. The entire mechanism is mounted on a single slate panel easily removed from the case by removing four screws. Conduit knock-out holes are provided in the top, bottom, and sides of the case.



Square D Safety Distribution Panel

A DISTRIBUTION panel of dead-front design, incorporating many safety features, has been announced by the Square D Company, Detroit, Mich. No live parts can be touched, even when the switch door is opened. Opening the switch instantly disconnects all live parts and leaves the fuses accessible in a fixed base, upon which is also mounted a switch. One of the chief features of the design, according to the announcement, is the switch element which is said to provide at least 50 per cent overload rupturing capacity without flashing over or breaking down.

The cam lever action of the door handle exerts high pressure upon closing the circuit and releases the door during the opening operation, so that the high-



contact pressures do not compel any great effort in the switch operation.

In addition to the interchangeability of the panel interiors with units of various sizes, each unit may be changed to fit larger or smaller fuses.

Simplex "Anoroc"

SIMPLEX WIRE AND CABLE COMPANY, 201 Devonshire St., Boston, Mass., has announced a rubber insulation called "Anoroc" which, it is claimed, entirely does away with corona and ozone troubles on high-voltage cables insulated with rubber compounds.

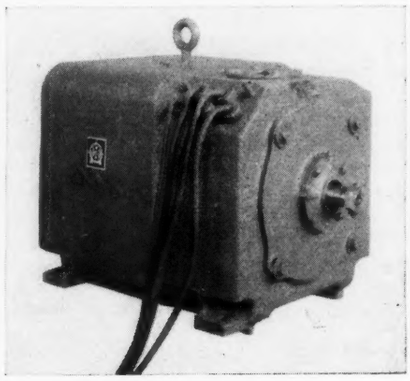
Worthington Acquires Gilman Manufacturing Company

WORTHINGTON Pump & Machinery Corporation, 2 Park Avenue, New York City, has taken over the manufacturing and distribution of the entire line of compressed-air tools and accessories of the Gilman Manufacturing Company, East Boston, Massachusetts.

Reliance Explosion-Proof Motors

AN explosion-proof motor built for d.c. operation has been introduced by the Reliance Electric & Engineering Company, Ivanhoe Road, Cleveland, Ohio.

According to the announcement the

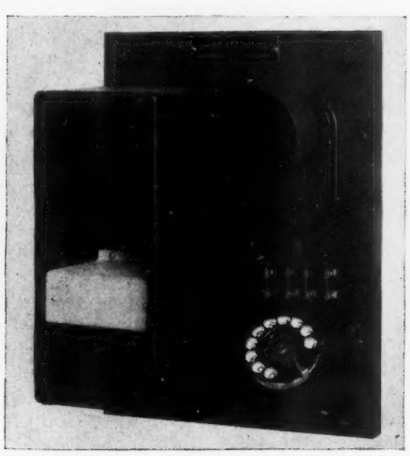


motor is so constructed that even if an explosive mixture of natural gas and air should leak inside, ignite and explode, the motor will withstand the explosion and not communicate sparks or flame to the outer air.

General Electric Audio Frequency Remote Control Equipment

EQUIPMENT for controlling the operation of remote, automatic electric devices by means of audio-frequency impulses has been announced by the General Electric Company, Schnectady, N. Y. Indications of electrical conditions from the remote equipment are given by means of audible signals, in contrast to previous methods using visual indications.

The control, known as the audible, selector-type supervisory equipment, is applicable to the operation of various types of electric machinery. Automatic hydro-electric generating plants in central station systems, automatic pumping stations, etc., may be controlled from a remote point.

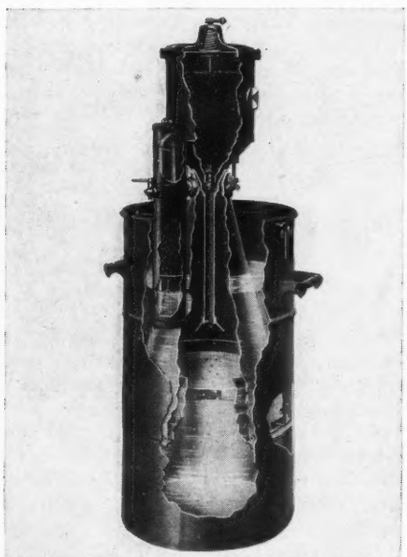


Supervising equipment consists of a wall panel on which are mounted a calling dial similar to those used on dial telephones, a reset key, a howler and an audio-frequency transmitter. The supervisory equipment, located in the outlying station which is to be controlled, consists of selector switches, auxiliary relays, etc., necessary to adapt the supervisory system to the control circuits of the devices supervised.

Harris Model No. 6 Acetylene Generator

PORTABLE, low-pressure, automatic acetylene generators, known as Model No. 6, are now being made by the Harris Calorific Company, Cleveland, Ohio. These units consist of three parts — the large tank, the generating cone, and the hopper. When fully charged the unit weighs 238 pounds.

Some of the features are: the carbide is not exposed to water or moist temperatures at any time until automatically



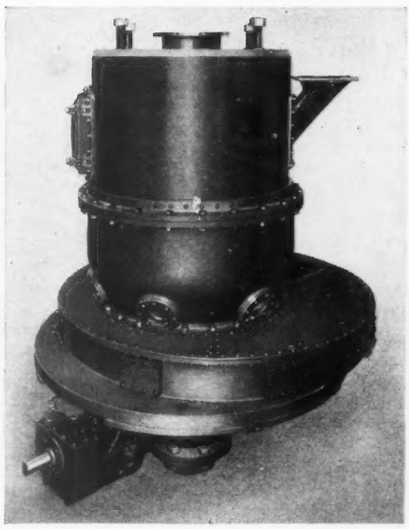
fed; it is contained in a gas-tight hopper; the valve controlling the carbide may be locked, or the entire hopper can be removed when transporting the generator.

Carbide feed is automatically controlled by the rise or fall of the water.

Fuller Lehigh Type B Pulverizer

A COAL pulverizer, designated Type B, has been placed on the market by the Fuller Lehigh Company, Fullerton, Pa. This device is an air separation ball mill which consists essentially of a top or separator section, an intermediate or pulverizing section, and a base or drive section.

The top section is of heavy steel-plate and cast-iron construction, containing

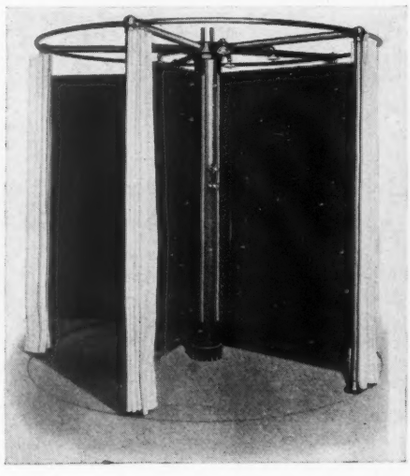


the classifying cone, coal spout, and mechanism for adjusting grinding pressure. The grinding elements, coal basket and driving yoke, are mounted in the intermediate section. The base or drive section incloses the air distributing chamber, main and thrust bearings, drive shafts and gears, and the force-feed oiling system.

Bradley "5-in-a-Group" Shower Fixtures

BRADLEY WASHFOUNTAIN COMPANY, Milwaukee, Wis., announces the addition of the Bradley "5-in-a-Group" shower to its line of group washing fixtures. The group shower is circular in shape and accommodates five users at once.

Among the developments in this fixture are: improved-type shower head of low water consumption; protection against clogging, by means of a Monel metal wire screen placed in the shower head itself; mixing chamber concealed in the central standard which allows tempering of water at any pressure; valves placed in each of the five compartments.



Clark Stock Chaser

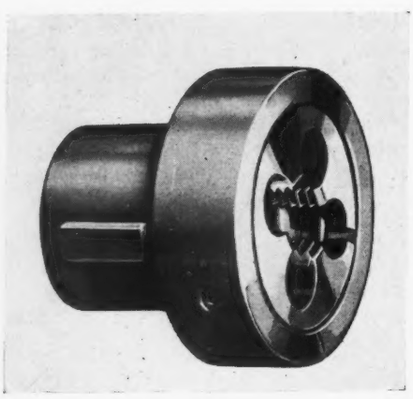
A THREE-WHEELED, gas-propelled tractor, equipped at the rear with a steel platform box 33½ x 29½ in., having a capacity of 500 lb., has been announced by the Clark Tructractor Company, Battle Creek, Mich. This unit, with its turning radius of 51 in., is recommended for taking tools, jigs, and fixtures from toolroom to machine, picking up special parts from storage, carrying mail, and other jobs of this nature around the plant.

The box at the back of the tractor

may be removed, thus converting the unit into a factory tractor with standard trailer coupler, capable of hauling 25 tons on trailers.

Borden Bolt Die Heads

BOLT die heads are now available for the No. 3 Beaver ratchet die stock (⅛ to 1 in.), announces The Borden Company, Warren, Ohio, mak-

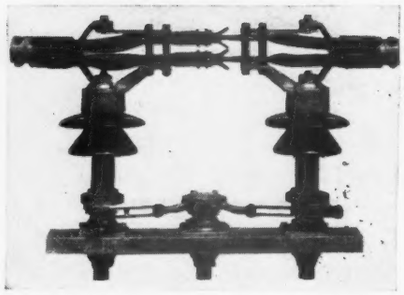


ers of this tool. The bolt die heads are obtainable in all sizes within the above range.

Delta-Star High-Voltage Switches

A LINE of high-voltage, heavy-capacity, horizontal-center-break, gang-operated switches for mounting on top or sides of outdoor substations has been introduced by the Delta-Star Electric Company, 2400 Fulton St., Chicago, Illinois.

Full-floating adjustable contacts and swivel-terminal connectors insure ease of operation from the center control bearing to which is connected the in-



terlocking operating mechanism. The single-pole element shown is rated, 3,000 amp. at 25,000 volts.

Dayton Roderwald "Link-Wedge" Belt

THE Dayton Rubber Manufacturing Company, Dayton, Ohio, is manufacturing and marketing the V-shaped "Link-Wedge" belt by arrangement with the Roderwald Company of Berlin, Germany.

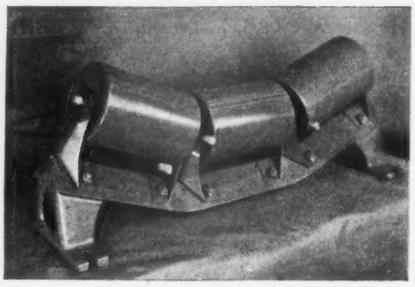
It is of fabric and rubber construction, with integral cogs on the inside and runs on a standard V-shaped pulley. The belt is flexible and adjustable to any length desired. A metallic clamp is used to join the ends.

Stephens-Adamson Simplified Belt Conveyor Carrier

A ROLLER-BEARING, belt-conveyor carrier, known as the "Pacific Type," has been developed by the Stephens-Adamson Manufacturing Company, Aurora, Ill. Timken bearings are used throughout.

As the illustration shows, it is of the three-roller, 20-deg. trough design. Construction is of heavy-gage pressed steel, with the exception of the end-stand castings.

Each roller turns upon two tapered roller bearings housed with an inner hub of steel tubing and protected from dust and moisture by an intermeshing-labyrinth grease seal for each bearing. The tapered roller bearings used are large in size and are arranged to carry end thrust as well as radial loads. Inner hub extends the full length of each roller and prevents any chance for misalignment of bearings.



Individual Alemite fittings are used on each bearing. The carrier is built in sizes for conveyor belts of from 18 to 48 in. wide.

Roller-Smith Portable Volt-Ammeter

TYPE PD pocket, portable, d.c. volt-ammeter is the latest addition to the line of instruments made by the Roller-Smith Company, 233 Broadway, N. Y. This model is 4½ in. wide, 5 in. long, and 1⅝ in. deep with a scale length of $3\frac{5}{16}$ in. The cover is of drawn metal and the case, molded Bakelite.

The movement is of the D'Arsonval type built on the upper side of a metal plate which also carries the binding posts and switches. Resistance spools,

shunts, etc., are carried on the lower side of this plate. Ceylon sapphire jewels are used for bearings. Pointers are of heavy construction to withstand the usage common in industrial service.

Electric Products Company Acquires Rochester Electric Products Corporation

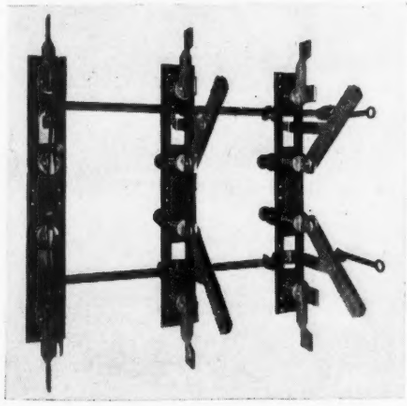
ACCORDING to a recent announcement, The Electric Products Company, Cleveland, Ohio, purchased the business of the Rochester Electric Products Corporation, Rochester, N. Y., manufacturers of diverter-pole generators. The Rochester plant has been closed and all activities have been transferred to Cleveland.

Newark Stainless-Steel Wire Cloth

THE Newark Wire Cloth Company, 351 Verona Ave., Newark, N. J., announces the marketing of wire cloth made of stainless steel. This cloth is made in all meshes, widths, and lengths.

Champion Disconnecting Switch

THE Champion Switch Company, Kenova, W. Va., has developed a stick-operated gang disconnect for pipe-frame mounting. Features include front and back connections, double, three-pole style rated at 15 kilovolts.



Individual phase rods are so designed that they pass over the center line in both open and closed positions, securing a positive lock in both positions.

Bronze operating shaft bearings have conical-shaped bushings permitting misalignment of individual phases without binding of the operating shaft. Insulators are of the solid, one-piece, high-strength type.

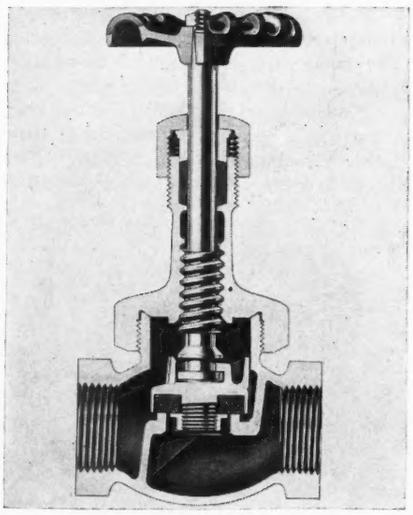
Torchweld Gasoline Cutting Torch

A METAL cutting torch which uses gasoline for fuel has been introduced by the Torchweld Equipment Company, Chicago, Ill. The torch is supplied as part of the cutting torch unit which consists of the following equipment: Torch, with four gasoline cutting tips; 25 ft. of high-pressure oxygen hose; 25 ft. of flexible metallic hose; a 2-gal. welded gasoline tank; a high-pressure, two-gage oxygen cutting cylinder regulator; wrenches; goggles, and gloves.

Jenkins Bronze Valves

STANDARD bronze valves with a one-piece, screw-over bonnet and slip-on, stay-on disk holder have been announced by Jenkins Bros., 80 White Street, New York, N. Y. These valves are made in globe, angle, cross, and check types for all standard services. The globe valve is designated as Fig. 106-A. The one-piece bonnet construction is said to provide ease in removal.

The slip-on disk holder facilitates changing the disk. If the spindle is raised just a turn or so, the bonnet

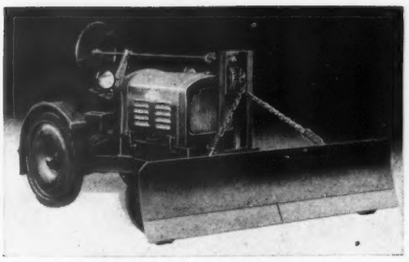


can be removed from the valve body without danger of the disk holder slipping off the spindle. A turn or so in the opposite direction and the disk holder slips off the spindle.

Clark "Clarktor" Snow Plow

FOR the removal of snow from platforms, runways, yards and alleys, the Clark Tructractor Company, Battle Creek, Mich., introduced the "Clarktor" snow plow, built on the Tructractor chassis. The adjustable blade has a renewable cutting edge of hardened alloy steel, which when lowered rides on two steel buttons that prevent the edge of the blade from striking minor pavement irregularities. The plow assembly is hung on heavy springs in the supporting chains. A path 74 in. wide is cleaned by the 82-in. blade. The plow assembly is easily removed and the Clark rotary broom may be substituted. The broom is 72 in. long and sweeps a path 60 in. wide.

Power and traction are supplied by the standard, gas-powered "Clarktor," four-wheeled industrial tractor. It has



a turning radius of 108 in. and develops 3,600 lb. draw-bar pull in low gear. Equipment includes self-starter, generator, battery, head and tail lights.

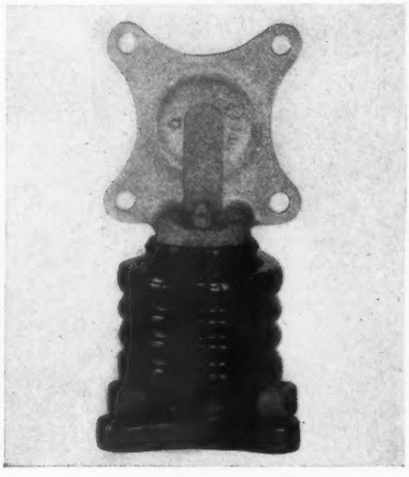
Cutler-Hammer Starting Switch

FOR convenient starting and stopping of small d.c. and polyphase motors, Cutler-Hammer, Inc., 150 12th St., Milwaukee, Wis., offers a bulletin 9103, two-pole, pushbutton-operated starting switch with thermal overload relays. This unit can be used with d.c. motors up to ½ hp., 115 volts, and ¼ hp. at 230 volts, or with a.c. motors—single-, two- or three-phase types, up to 2 hp., 110 to 550 volts. The inclosing case is a standard wiring box and can be mounted right on the machine. For machinery builders, an open-type switch for building directly into the machine is offered.

General Electric Non-Magnetic Bus Fittings

A LINE of non-magnetic bus clamps and bus-support fittings is announced by the General Electric Company, Schenectady, N. Y. The fittings are made of non-magnetic steel with a circular ridge or raised portion located centrally on the face of the clamp which transmits and distributes the clamping bolt pressure to the bus contact surfaces.

The design obviates the tendency of the bus bars to bow away from each other at the center when the clamps are tightened.



Electric Specialty Dynamotors and Motor Generators

A LINE of "ESCO" dynamotors and motor generators, for operating a.c. apparatus from direct current, has been announced by the Electric

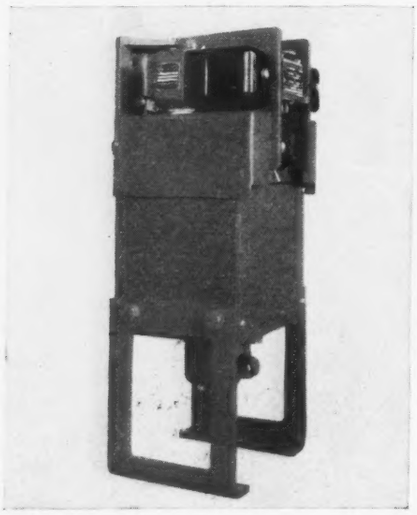
Specialty Company, Stamford, Conn. All units are equipped with wool-packed bearings. They are semi-inclosed for protection. Dynamic balance eliminates vibration. Wiring is totally inclosed for safety. Both high- and low-speed equipment is available.

General Electric Solenoid-Operating Mechanisms

SOLENOID-OPERATED, d.c., switchgear mechanisms, designated Types SD-17 and SD-19, which are trip free at any point of the closing stroke, have been introduced by the General Electric Company, Schenectady, N. Y. The mechanism operates in conjunction with a control relay and a remotely mounted control switch. Emergency manual operation is obtained by means of a removable manual-closing device which can be assembled for operation either from the side or the front, as desired.

Features mentioned are the noncorrosive main bearings, provision for multiple-stage auxiliary switches conveniently located and operated by the solenoid mechanism, and the terminal blocks located directly below the auxiliary switches, easily accessible by removing the inclosing cover.

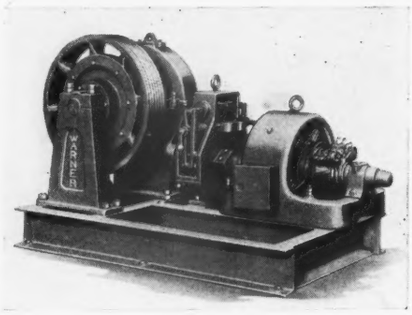
These trip-free mechanisms are used with the various types of moderate- or high-duty G.E. oil-circuit breakers.



Warner Elevator Machines

ELEVATOR machines with motor and brake suitable for use with variable-voltage control on either a.c. or d.c. supply, have been announced by the Warner Elevator Manufacturing Company, Cincinnati, Ohio. These units can also be provided with a single-speed a.c. motor for switch or push-button control.

The bed plate is built of 8-in. ship channels, arc-welded and planed on top. The drum shaft is fixed, and the spiders bearing the drum and worm gear rotate on Timken bearings within the common hub of these spiders. Bearings are lubricated by means of Alemite fittings. The traction drum is a steel casting and is



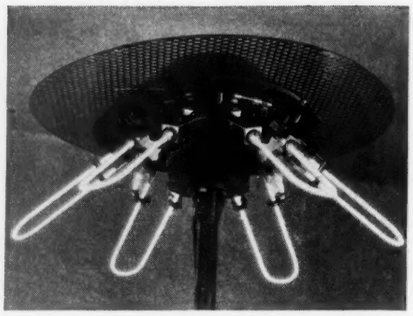
demountable, being fitted to a heavy spider by means of flange bolts. The worm is of hammered steel mounted in plain babbitted bearings. Thrust in both directions is taken by two oversize angular-contact ball bearings mounted on the free end of the shaft.

Westinghouse Guide and Obstruction Marker

A LIGHT for marking industrial obstacles hazardous to airplanes has been developed by the Westinghuose Electric & Manufacturing Company, East Pittsburgh, Pa. These markers are composed of six U-shaped Neon tubes.

These tubes are connected in series, but should one or more become defective, it is cut out of the circuit by an automatic cutout. The marker will remain in service as long as one active tube is left.

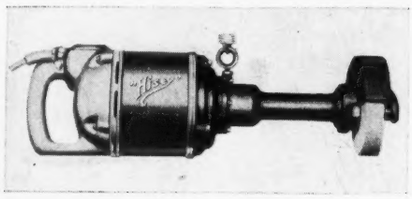
Markers have pedestal-type mountings which may be bolted to any solid support. For operation on low voltages, a transformer is mounted directly



under the hood. When used for marking transmission towers, or where high voltages are available, the marker may be connected directly across the line.

Hisey-Wolf Grinders

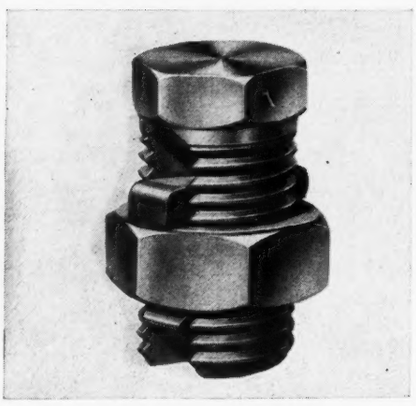
PORTABLE hand grinders in 1- and 2-hp. sizes are being made by The Hisey-Wolf Machine Company, Cincinnati, Ohio. They can be used on either a.c. or d.c. circuits.



Single-phase a.c. machines, which can be operated from a convenient lamp socket, are equipped with improved repulsion induction motors. Ball bearings are used in the motors, whereas roller bearings are used in the grinding spindle.

Matthews Solderless Service Connectors

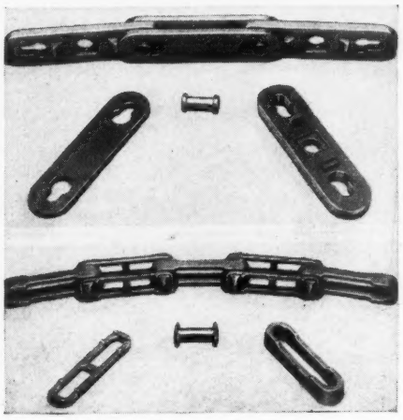
SOLDERLESS service connectors made in 8 sizes have been introduced by the W. N. Matthews Corporation, St. Louis, Mo. These connectors are made of yellow brass but can be furnished also in red brass or bronze, if desired.



Transue & Williams Standard and Light-Service Conveyor Chains

DROP-FORGED standard and light-service conveyor chains have been placed on the market by the Transue & Williams Steel Forging Corporation, Alliance, Ohio. The standard chain is of rivetless straight-line construction with interchangeable pintles. It is made in five different weights, ranging from 3.11 to 16 lb. per linear foot.

The light-service conveyor chain is rivetless and light in construction, the 4-in. pitch having a weight of 2.2 lb. per ft. It has a permissible radius travel of 3 ft. Backlash is taken care of by



a locking device. The tensile strength is approximately 14,000 lb., whereas that of the standard chain ranges from 30,000 lb. up without being heat-treated.

Hamilton Sangamo Electric Clocks

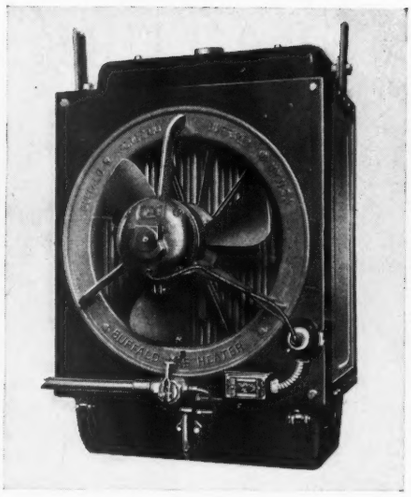
SYNCHRONOUS wall clocks are now being offered to the industrial field by Hamilton-Sangamo Corporation, Lancaster, Pa. They have neither movement nor escapement as in the case of handwound clocks.

Time is measured by means of a slow-speed motor which receives its impulses from the maintained frequency of the central generating station. The clocks require no winding and run as long as current flows through the meter.

Buffalo Forge Gas-Fired Unit Heaters

GAS-FIRED unit heaters are now being made by the Buffalo Forge Company, Buffalo, New York. Heaters are made with the fan drives suitable for operation on single-phase, three-phase, and d.c. 110- or 220-volt circuits.

Brass tubes arranged in staggered rows constitutes the heat interchanging element. Louvers in the discharge opening are adjustable to deflect the air



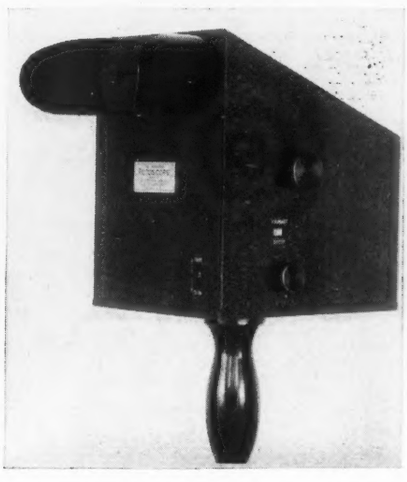
where desired. Air delivery is 2,300 c.f.m. The flame is inclosed in a metal combustion chamber and is visible through a Pyrex glass window. A safety pilot shuts off the motor and gas should the flame go out.

The gas burner consists of tubes, each with its own orifice. The amount of gas consumed can be controlled by an adjusting screw on the gas valve. To simplify inspection and cleaning, the burner pan is hinged at the back and held in place by three hand clamps.

Ashdown Rotoscope

AN instrument operating on the Stroboscopic principle and known as the Ashdown Rotoscope is now being distributed in this country by Livingston & Southard, Inc., 17 Battery Place, New York, N. Y. The device is used to obtain the speed of any rapidly moving object without physical contact with the object itself. It also enables the observer to make a slow-motion study of moving parts.

The chief feature of the instrument is the rotary cylindrical shutter which is capable of giving as many as a thousand glimpses per second, which blend



into a continuous impression on the retina of the eye. This shutter speed can be varied by adjusting a five-speed gear box. Fine speed control is secured by means of a special centrifugal governor, thus achieving, it is claimed, an accuracy well within 0.5 per cent. The instrument weighs 6 lb. and is operated by clock work.

Turner Pressure Lubricators

INTERNALLY developed pressure, capable of projecting a stream of oil a distance of 12 ft., is one of the features of the line of lubricators intro-

duced by The Turner Brass Works, Sycamore, Ill. According to the announcement, the amount of lubricant ejected may be varied from a few drops to a fine stream.

General Electric Instrument Current Transformers

INSTRUMENT current transformers, embodying compensating features which are claimed to practically eliminate ratio and phase-angle errors, and bearing the designation WF-1, have been

announced by the General Electric Company, Schenectady, New York.

These transformers, built in ratings from 5 to 800 amp. and designed for 5,000-volt operation, are for use in connecting watt-hour meters, instruments and relays, the combined burden of which does not exceed 50 volt-amp. These units supersede the WC-12 with which they are interchangeable as to dimensions. They are arranged for either flat-surface or pipe mounting. Two-bolt-hole terminals are used.

TRADE LITERATURE

You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog described, as given in these columns.

* * *

(291) PUMPS—Bulletin 14, 8 pages, several types of centrifugal pumps and their applications. — Chicago Pump Company, 2337 Wolfram St., Chicago, Ill.

(292) INSULATION — Manual No. 102, "Service to the Power Plants."—Johns-Manville Corporation, 292 Madison Ave., New York, N. Y.

(293) INSTRUMENTS — Catalog 80, resistance thermometers; No. 90, "The Hump Method for Heat Treatment of Steel;" Bulletin 880, direct-reading humidity recorder.—Leeds & Northrop Company, 4901 Stenton Ave., Philadelphia, Pa.

(294) FUSE CUTOUTS—Bulletin 508, a line of wet-process, porcelain-housed cutouts and disconnecting switches.—W. N. Matthews Corporation, St. Louis, Mo.

(295) MOTORS—Bulletin 7, fully inclosed, fan-cooled, ball bearing equipped induction motors for two- and three-phase circuits.—Reliance Electric & Engineering Company, Ivanhoe Road, Cleveland, Ohio.

(296) OIL-ELECTRIC LOCOMOTIVES—Special publication 1880, 60 pages, application, operation, and construction details on oil-electric traction apparatus and photographs and diagrams of many locomotives and cars.—Westinghouse Electric & Manufacturing Company, E. Pittsburgh, Pa.

(297) COPPER BRAZING—Bulletin GEA-1291, 20 pages, copper brazing and copper-brazing furnaces.—General Electric Company, Schenectady, New York, N. Y.

(298) MOTORS—Publication GEA-1152A, synchronous motors for pumping.—General Electric Company, Schenectady, N. Y.

(299) FEED-WATER HEATERS — Booklet, 12 pages, details of the Patterson-Berryman and Standard feed-water heaters.—Patterson-Kelley Company, 101 Park Ave., New York, N. Y.

(300) WELDING — Bulletin 6, unbeveled plate welding.—Fusion Welding Corporation, 103rd St. and Torrence Ave., Chicago, Ill.

(301) AIR COMPRESSORS—Bulletin 153, two-stage, tandem-types; Bulletin 151, duplex two-stage and duplex single-stage types.—Pennsylvania Pump and Compressor Company, Easton, Pa.

(302) LIFT TRUCK—Bulletin 92J, "Red Giant" lift truck.—Revolvator Company, 336 Garfield Ave., Jersey City, N. J.

(303) ACCESSORIES — Folder, "Elastic" stop nuts.—A. G. A. Company, Elizabeth, N. J.

(304) WELDING — Folder, Weldite green-surfaced welding rods. — Fusion Welding Corporation, 103rd St. and Torrence Ave., Chicago, Ill.

(305) STANDARDS — Report to the American Standards Association on conference held in Paris, May, 1930, by John Gaillard.—American Standards Association, 29 West 39th St., New York, N. Y.

(306) BELT CONVEYOR—Folder 1248, "Cub" portable belt conveyor.—Link-Belt Company, 910 South Michigan Ave., Chicago, Ill.

(307) PANELBOARDS—Special Publication 1890, 12 pages; specifications and illustrations showing construction.—Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

(308) PUMPS — Catalog E 1140, 40 pages; pumps, turbines, compressors and speed reducers for the oil industry.—De Laval Steam Turbine Company, Trenton, New Jersey.

(309) MATERIALS HANDLING — "Economical Material Handling," 63 pages; installations of conveying equipment.—The Louden Machinery Company, Fairfield, Iowa.

(310) CONTROL EQUIPMENT—Architects' and Engineers' Bulletin No. 291, Bull Dog Saftofuse power and light electric "centrols," distributing feeder panelboards.—Bull Dog Electric Products Company, Detroit, Mich.

(311) CHAIN DRIVES—Catalog 78, 64 pages; stock chain drives. — Diamond Chain and Manufacturing Company, Indianapolis, Ind.

(312) CONTROL EQUIPMENT — Bulletin, 32 pages; automatic control equipment.—Brown Instrument Company, Wayne and Roberts Ave., Philadelphia, Pa.

(313) LOCOMOTIVES—Publication GEA-1230A, 30-ton, gas-electric industrial haulage types.—General Electric Company, Schenectady, N. Y.

(314) REFRACTORIES — Folder "Mono" boiler baffling.—Southern King Refractories, Inc., 489 Stephens St., S. W., Atlanta, Ga.

(315) ELECTRICAL TOOLS—Catalog 36, 64 pages; electrically driven drills, grinders, buffers, and polishers. — Standard Electrical Tool Company, 1938 West 8th St., Cincinnati, Ohio.

(316) ENGINEERING BULLETIN—Volume 1, No. 4, suggested A. S. T. M. specifications for open-hearth plates.—The American Rolling Mill Company, Middletown, Ohio.

(317) ELECTRICAL EQUIPMENT—Bulletin, 12 pages; "Controlead" terminal blocks.—Burke Electric Company, Erie, Pa.

(318) MATERIALS HANDLING EQUIPMENT—Bulletin, 16 pages; complete line of both standard and special floor trucks.—Lewis-Shepard Company, Watertown Station, Boston, Mass.

(319) RUBBER — Bulletin, 12 pages; "Covulc," a self-vulcanizing rubber compound.—Hitchcock Company, 48 Pearl St., Boston, Mass.

(320) SAFETY — "Making the Plant Safe," the ninth of a series of reports on industrial safety. — Policy Holders Service Bureau, Metropolitan Life Insurance Company, New York, N. Y.

(321) LIGHTING—Handbook, 48 pages; "A Guide to Productive Lighting," compiled by the illuminating engineering department.—Benjamin Electric Manufacturing Company, Des Plaines, Ill.

(322) GEARS—Catalog 30, 96 pages; complete line of small and medium size gears.—Ohio Gear Company, 1333 East 179th St., Cleveland, Ohio.

Coming Events

Ninth National Exposition of Power and Mechanical Engineering — Grand Central Palace, N. Y., Dec. 1 to 6, 1930. Managers, International Exposition Company.

American Institute of Electrical Engineers—Annual winter convention, New York City, Jan. 26-30, 1931. Secretary, F. L. Hutchinson, 33 W. 39th St., New York, N. Y.

Fifth Midwest Engineering and Power Exposition—Coliseum, Chicago, Feb. 10 to 13, 1931. Managers, Midwest Engineering Exposition, Inc., 308 W. Washington St., Chicago, Ill.

Second National Western Metal Congress and Exposition—Civic Auditorium, San Francisco, Calif., Feb. 16-20, 1931. Under auspices of A.S.S.T. W. H. Eisenman, secretary, 7016 Euclid Ave., Cleveland, Ohio.

Second National Industrial Congress Featuring Management, Maintenance and Materials Handling—Public Auditorium, Cleveland, Ohio, April 13 to 18, 1931, inc. In conjunction, Second National Industrial Equipment Exposition. Concerning technical sessions address P. T. Wetter, American Society of Mechanical Engineers, 29 West 39th St., New York City. Exposition under management Midwestern Engineering Exposition. 308 West Washington St., Chicago, Ill.

National Fire Protection Association—35th annual meeting, Toronto, Can., May 11 to 17, 1931. Association headquarters, 60 Batterymarch St., Boston, Mass.

National Electric Light Association—54th convention and exhibition, Municipal Auditorium, Atlantic City, N. J., June 8 to 12, 1931. Frank H. Gale, Secretary-Treasurer, 420 Lexington Ave., New York, N. Y.

INDUSTRIAL ENGINEERING'S DATA SHEETS

Motor Wiring Tables

(Continued from the October issue)

THREE-PHASE, WOUND-ROTOR AND THREE-PHASE, HIGH-REACTANCE TYPE SQUIRREL-CAGE INDUCTION MOTORS

Voltage	Hp.	Full load Amperes	Wire Size Gage No. or circular mils			Conduit size for r. c. wire Inches	Running protection		Max. rating branch circuit fuses		Voltage drop per 100 ft. (single distance) r. c. wire Percent
			Rubber covered	Varnished cambric	Slow-burning		Max. fuse rating** Amperes	Max. setting time limit protective device Amperes	Wound-rotor Amperes	High-reactance type Amperes	
110	1	7.8	14	14	14	½	10	9.75	15	20	3.2
	2	14.4	12	12	14	¾*	20	18.00	25	40	3.8
	3	20.0	10	12	12	¾	25	25.00	30	50	3.3
208	1	4.1	14	14	14	½	6**	5.25	15	15	0.9
	2	7.6	14	14	14	½	10**	9.50	15	20	1.7
	3	10.6	14	14	14	½	15	13.25	20	30	2.3
	5	16	12	12	14	¾*	20	20.00	25	40	2.2
	7½	26.5	8	8	8	1*	35	33.5	40	70	1.4
	10	30	6	8	8	1¼*	40	37.5	45	80	1.0
	15	48	4	6	6	1¼	60	60.0	80	100	1.0
	20	59	3	4	4	1½	80	74	90	120	1.0
	25	71	2	3	4	1½	90	89	110	150	1.0
	30	87	0	2	2	2	110	109	150	175	0.74
	40	112	00	0	1	2	150	140	175	225	0.76
	50	136	000	00	0	2	175	170	225	300	0.73
	60	159	0000	000	0	2½	200	199	250	350	0.68
	75	200	250,000	0000	000	2½	250	250	300	400	0.72
	100	261	400,000	300,000	0000	3	350	326	400	600	0.47
	125	330	600,000	500,000	350,000	3½	450	413	500	660***	0.50
	150	386	700,000	500,000	400,000	3½	500	483	600	772***	0.50
	200	520	1,000,000	800,000	600,000	4		650	780***	1040***	0.47
220	1	3.9	14	14	14	½	6*	5.00	15	15	0.81
	2	7.2	14	14	14	½	10*	9.00	15	20	1.5
	3	10.0	14	14	14	½	15	12.50	15	25	2.1
	5	15	12	12	14	¾*	20	18.75	25	40	2.0
	7½	25	8	8	8	1*	35	31.50	40	70	1.3
	10	28	8	8	8	1*	35	35.00	45	70	1.5
	15	45	4	6	6	1¼	60	56.50	70	90	0.9
	20	56	4	4	6	1¼	70	70.00	90	120	1.1
	25	67	2	4	4	1½	90	84.00	100	150	0.86
	30	82	0	2	2	2	110	102.5	125	175	0.67
	40	106	00	0	1	2	150	132.5	175	225	0.69
	50	128	000	00	0	2	175	160.0	200	275	0.65
	60	150	0000	000	0	2½	200	187.5	225	300	0.60
	75	188	250,000	0000	000	2½	250	235	300	400	0.64
	100	246	400,000	300,000	0000	3	300	308	400	500	0.60
	125	310	500,000	400,000	300,000	3	400	388	500	620***	0.53
	150	364	600,000	500,000	350,000	3½	450	455	600	728***	0.52
	200	490	900,000	800,000	500,000	4		613	735***	980***	0.46

INDUSTRIAL ENGINEERING'S DATA SHEETS

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(Continued from the preceding page)

THREE-PHASE, WOUND-ROTOR AND THREE-PHASE, HIGH-REACTANCE TYPE SQUIRREL-CAGE INDUCTION MOTORS—*Continued*

Voltage	Hp.	Full load Amperes	Wire Size Gage No. or circular mils			Conduit size for r. c. wire Inches	Running protection		Max. rating branch circuit fuses		Voltage drop per 100 ft. (single distance) r. c. wire Percent
			Rubber covered	Varnished cambric	Slow-burning		Max. fuse rating** Amperes	Max. setting time limit protective device Amperes	Wound-rotor Amperes	High-reactance type Amperes	
440	1	2	14	14	14	½	3**	2.50	15	15	0.21
	2	3.6	14	14	14	½	6**	4.50	15	15	0.37
	3	5	14	14	14	½	8	6.25	15	15	0.52
	5	7.5	14	14	14	½	10	9.50	15	20	0.78
	7½	13	12	14	14	¾*	20	16.25	20	35	0.85
	10	14	12	14	14	¾*	20	17.50	25	35	0.91
	15	23	8	10	10	1*	30	29.0	35	60	0.59
	20	28	8	8	8	1*	35	35.0	45	70	0.72
	25	34	6	6	8	1¼*	45	42.5	60	70	0.55
	30	41	4	6	6	1¼	50	52.5	70	90	0.67
	40	53	4	4	6	1¼	70	66.5	80	110	0.54
	50	64	3	4	4	1¼	80	80.0	100	150	0.52
	60	75	1	3	3	1½	100	94.0	125	150	0.38
	75	94	0	1	2	2	125	117.5	150	200	0.38
	100	123	000	00	0	2	175	154.0	200	250	0.31
	125	155	0000	000	0	2½	200	194	250	350	0.31
	150	182	250,000	0000	000	2½	250	228	300	400	0.31
	200	245	350,000	250,000	0000	3	300	307	400	500	0.30
550	1	1.6	14	14	14	½	2**	2.00	15	15	0.13
	2	2.9	14	14	14	½	4**	3.75	15	15	0.24
	3	4	14	14	14	½	6	5.00	15	15	0.33
	5	6	14	14	14	½	8	7.50	15	15	0.50
	7½	10	14	14	14	½	15	12.50	15	25	0.82
	10	11	14	14	14	½	15	13.75	20	30	0.91
	15	18	10	12	12	¾	25	22.5	30	45	0.59
	20	22	8	10	10	1*	30	27.5	35	60	0.45
	25	27	8	8	8	1*	35	34	45	70	0.55
	30	33	6	6	8	1¼*	45	41.5	50	70	0.43
	40	42	4	6	6	1¼	50	52.5	70	90	0.34
	50	51	4	4	6	1¼	70	64.0	80	110	0.42
	60	60	3	4	4	1¼	80	75	90	120	0.39
	75	75	1	3	3	1½	100	94	125	150	0.30
	100	99	0	0	2	2	125	124	150	200	0.32
	125	124	000	00	0	2	175	155	200	250	0.25
	150	145	0000	000	0	2½	200	181.5	225	300	0.23
	200	196	250,000	0000	000	2½	250	245	300	400	0.27

*Conduit one size smaller can be used under certain conditions. N. E. C. 503-q.
**Motors of 2 hp. or less may be protected by the branch circuit fuses only. N. E. C. 808-a exception (1).
***Circuit-breaker setting. Fuses not permitted. N. E. C. 805-a, 808-a, exception (5).